2012
Specialty Crop Block Grant Program – Farm Bill (SCBGP-FB)
FINAL REPORT

USDA, AMS Agreement No:
Specialty Crop Agreement No. 12-25-B-1448

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Date Submitted:
March 2, 2016

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California Department of Food and Agriculture
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SPECIALTY CROP BLOCK GRANT PROJECTS

USDA Project No.: 1	**Project Title:** California Food Systems Alliance Network	
Grant Recipient: Ag Innovations Network	**Grant Agreement No.:** SCB12001	**Date Submitted:** December 2015
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Project Summary

California specialty crop producers have long sought to increase public understanding of the contribution of agriculture, acceptance of agricultural practices, and support for policy and attitude changes that lead to agriculture's success. The California Food System Alliance Network (FSA Network) project addresses these needs directly by creating, facilitating and building capacity in coalitions of producers, health experts, environmental stewards, and other community leaders interested in preserving the long-term viability of specialty crop agriculture.

This projects' purpose is to respond to requests to establish new county FSAs to provide venues for collaboration between specialty crop agriculture and local communities, such as FSAs and food policy councils, by creating tools that enable collaborative leaders to start and manage these coalitions, including development of a set of trainings, tools, and resources to support Alliances' and other food and agriculture collaboratives' efficacy; Increase the collective effectiveness of the FSAs by improving the capacity to act together on issues of statewide importance; disseminate throughout the FSA Network the best practices for influencing local community attitudes, county regulations and relationships needed for effective action on behalf of specialty crop agriculture; assist each FSA in identifying a platform for local communications, and develop programs that link specialty crop producers with new or emerging markets.

Initially, the project sought to launch and provide ongoing staff support to four new county-based Alliances. In June 2014, the project was revised and approved to launching two new coalitions and creating and implementing tools to enable collaborative leaders to start and manage these collaborations. This included the launch of the Contra Costa and San Diego Food System Alliances, creation of an abbreviated process design, and the development and implementation of trainings, tools, and resources to support Alliances' and other food and agriculture collaboratives. In addition, a robust transition plan to support the FSAs' moving to a self-management model was developed and executed in all Alliances. This revision facilitated the expansion of collaborative leadership in support of specialty crop agriculture through the FSA Network and other collaboratives across the California state, and provided them the capacity and expertise needed to implement projects both regionally and statewide

specialty crop production is experiencing new scrutiny by a public now concerned equally about health, economic viability, and environmental performance. In addition, communities are demonstrating an elevating awareness and involvement in Specialty crop agriculture-related issues including Farm to School, local procurement and distribution, marketing and branding, land availability, housing, workforce development, access to healthy food, etc. The FSA project taps into these trends and opportunities by connecting the public with producers and engaging them in joint problem-solving on common issues, such as government regulation, access to food, local specialty crop procurement, economic vitality, public health, and water quality/resources.

The FSAs act as a clearinghouse for complex, county-level issues impacting California specialty crop production and producers. The complexity of pressures facing growers requires a network of allies on both local and state levels. This is the role of the FSAs – to channel public desire for food system improvements into new coalitions of local actors who advocate in the interest of specialty crop producers and not at cross-purposes to those interests. The FSA Network was designed to connect producers with the communities they serve, and to cultivate untraditional allies with health, environmental, urban and other community stakeholders. The relationships developed in the Alliances produce significant, carefully vetted initiatives such as addressing the need for farmworker housing, regulatory improvements, and educational programs for the public.

This project builds upon 2009 Specialty Crop Block Grant Program project 4: *California Food System Alliance Project*, which expanded the FSA Network into three new counties and to work in new, agriculturally vibrant areas of the state. In addition to the four original FSAs, Sonoma, Santa Clara and Fresno counties were identified for Alliance expansion.

Project Approach

This project built on previous work by expanding and strengthening the Network in response to requests from new counties and by supporting the statewide network to be an effective voice and organizer in support of specialty crop agriculture across regions. Throughout the project duration, AIN provided service to two more Alliances (Contra Costa, San Diego counties) and designed and implemented a robust capacity-building program to foster coalition independence.

Producer Advisory Council (PAC): The PAC was established in early 2013 to ensure an elevated, regular avenue for the voice of specialty crop growers throughout the Alliance project. The group met quarterly by conference call in 2013-2014, providing vital direction to specialty crop Block Grant Program projects including the Alliance Transition, Capacity-Building Services, Salon Series and Alliance Toolkit. Objectives were threefold: to provide specialty crop growers' priorities to Alliances, a forum for collaborative learning and problem-solving, and advice on how the project activities can best serve the needs of specialty crop growers.

Alliance Transition: In conjunction with the PAC, AIN designed and executed a transition plan to support Alliances implementing self-management model. Each FSA was offered a suite of services (below). Ongoing support was provided until each transitioned (December 2014/January 2015) and three additional capacity-building projects were completed in years 2014-2015 (Attachment A, Alliance Transition).
Alliance Toolkit: Creation, distribution and training.
Coalition Management & Administration: Membership, logistics communications, committees
Collaborative Leadership Training was developed and offered to all groups
Organizational Development: Facilitation, process design, action planning, project management, membership/recruiting processes, Charter/Constitution revision
Communications Planning & Assistance: Website management and content development, documentation and file transfer, ongoing communications support (posting, promoting)

Ongoing FSA/Coalition Support: Support was continuously provided to Alliances (through the transition); services included process design, facilitation, agenda creation, meeting notes/results, recording and tracking of action items, communications support, committee management, documentation, project support, member tracking and coalition logistics.

Alliance Toolkit: AIN developed a toolkit of more than thirty tools, templates, and guides for the management of a multi-stakeholder collaborative initiative. Topic areas include: action and committees, monthly meetings, program planning, communications, process guides for FSA activity, membership/recruitment, and a range of additional resources. The toolkit represents AIN's industry knowledge from more than fifteen years of managing California agriculture/food system collaborations. The toolkit was distributed across the Network and a webinar to review in more detail was held in May, 2014.

New Alliance Launch & Abbreviated Process Design: In January, 2014, AIN launched a new Alliance in Contra Costa County (CCFSA) utilizing a new abbreviated process design with a focus on leadership and capacity-building for self-management, and long-term sustainability. The launch process included: establishment of specific conveners, interviews with key stakeholders to develop a targeted list of invitees, and hosting an open house meetings to ensure a strong connectivity with the local specialty crop agriculture contingency. The process design was developed into a twelve-month roadmap that emerging food system coalitions can follow to develop and manage an effective body.

Capacity-Building Services (CBS): As a major feature of the 2012 redesign, a suite of CBS were developed to support Alliances transitioning to a self-management model. These services benefited existing Alliances, and three special projects were initiated with non-Alliance collaboratives to improve their capacity to act together in service to specialty crop agriculture and their local food systems. The PAC advised that more intensive projects with fewer coalitions would most benefit the specialty crop industry, stressing the need for increased group capacity and the ability to collaborate better to improve specialty crop agriculture and food system outcomes. AIN developed a project scope and completed outreach to over fifteen coalitions in early fall of 2014, completing interviews with six. Projects in Mendocino and Santa Barbara counties were selected (Attachment A, CBP 1-Pager). AIN partnered with two community coalitions interested in developing policies and projects whose outcomes will benefit specialty crop growers.

Group Assessment Tool: An extensive group assessment tool was developed to improve coalitions' internal and external operations to better connect with and serve specialty crop producers, and enable stronger coalitions. The assessment was piloted in Mendocino County and remains a free tool for coalitions to utilize. (Attachment A, Assessment Tool)

Mendocino County Food Policy Council (MCFPC): AIN led the MCFPC through a five-month process to identify common goals, implement a new meeting design to improve collaboration and effectiveness, and develop new strategies to improve specialty crop producer engagement and services. The project included: group assessment/evaluation, identification and arrangement of group priorities, final recommendations on activities, action planning, meeting redesign, and evaluation. The project concluded in June, 2015.

Santa Barbara Food Action Plan (SBFAP): In June, 2014, PAC members reported the launch of a new SBFAP project, highlighting a number of impacts and opportunities for specialty crop growers and suggesting it as a CBS project. AIN launched a multi-month project; a four-phase process was designed (launch, data collection, report development, outreach and implementation) and AIN is providing enhanced facilitation and staff support to the SBFAP. In addition to developing a strategy-based blueprint, this project has brought together a broad group of members interested in implementing the SBFAP to improve coordination between local agencies and decision-makers, give voice to the concerns of stakeholders, serve as a public forum for key food system issues, build relationships between support organizations, these relationships and strategies will coalesce to improve specialty crop production, and targeted outreach to specialty crop producers was completed. No lobbying activity was engaged in at any time during this project.

Collaborative Leadership Training (CLT): AIN developed and began providing the CLT in spring, 2014. CLTs were offered in transitioning counties; trainings were held in five Alliances, and the CLT remains a free tool to California food system coalitions – Sonoma, Fresno, Contra Costa, San Diego, Santa Clara, and participant evaluations were completed, compiled and submitted. The CLT was designed to increase the capacity of members and coalitions to serve as leaders and change makers in the context of collaborative approaches to food system change. California agriculture advocates are by and large strong leaders in their communities but their individual actions can be solo and in some cases duplicative or at cross-purposes. Trainings focused on individual and group leadership, facilitation and process skills, effective collaboration, food system literacy, and collective impact. The CLT project includes a: 1-Pager, presentation, agenda, handouts and detailed curriculum.

Statewide Projects: Salon Series, Food System Assessments, & Producer Advisory Council Brief
Salon Series: In 2014, AIN offered a series of capacity-building webinars to Alliances and food system groups across the state. During bi-monthly learning webinars, food system leaders connected with hundreds of stakeholders, communicated county priorities, learned new tools and shared best practices for collaborative change. Topics focused on the "how-to’s" of food system change, with each featuring an expert presenter on the topic at hand.

Salon Series 1-Pager including links to all materials/videos:
Priority-Setting & Action Planning, Sonoma County Healthy & Sustainable Food Action Plan, California Drought Special, Building a Resourceful Alliance (Toolkit Review), Food System Thinking: System Theory, Using Teams Effectively: Strategies for leveraging committees to do more, and how local food system collaboratives can become innovation engines

Food System Assessments: Replicating the initial work of the Sonoma FSA, the Santa Clara and San Mateo FSAs completed food assessments, and the Contra Costa FSA’s assessment project is underway. The SMFSA assessment reports on the unique history, status and challenges of specialty crop production while demonstrating how invaluable a viable, thriving specialty crop industry is to local public health objectives and economy. The SMFSA not only took lessons learned from Sonoma and the Santa Clara FSA about how to effectively conduct an assessment using collaborative process, but replicated the way Sonoma has used the data as a foundation for action to improve the future of specialty crop agriculture in their community. To further their findings in San Mateo, the SMFSA produced a Feasibility Study to discover opportunities that support a thriving, local food system. In turn, the new Alliance in Contra Costa established an assessment committee and continues to follow the design/process similar to Sonoma, Santa Clara and San Mateo. Following the Alliance transition, the CCFSA leveraged funding and continues to develop this project with anticipated completion in late 2015 year.

Producer Engagement Brief: Citing ongoing difficulties in retaining the specialty crop producer voice in food system work across the Network, the PAC produced an informal brief on encouraging producer engagement via meeting structure, content, and topics of interest. The Producer Engagement Brief was distributed to over twenty-five California county FSAs, food policy councils and coalitions.

Statewide Collective Action: In 2011, AIN launched a statewide project addressing regulatory issues in California agriculture in response to requests from agricultural, conservation, and public sector partners at both the state and local level. The project sought solutions that reduce the challenges associated with regulatory compliance for farmers while also meeting the underlying public goals of regulation. The project culminated in a 2014 report entitled Regulating for Agricultural and Public Outcomes. Several recommendations with the potential for county-level impact were identified and presented to Alliances as an opportunity to engage on and move forward in their own counties. AIN created an outreach strategy for Alliances use to reach out to local decision-makers and request their leadership on regulatory burdens impacting specialty crop agriculture.

Objectives: Foster communication and collaboration toward minimizing regulatory challenges; build a common understanding of key regulatory issues across stakeholder groups; establish connections between those concerned with/already working on key issues; identify and advance both short- and long-term solutions that minimize challenges associated with regulatory compliance for California specialty crop farmers and complement/expand upon existing local/statewide efforts to decrease regulatory burdens.

Results: This project was piloted in existing Alliance counties, each of which was already working to streamline complex regulatory and permitting environments. Each FSA expressed general support for the project concept and reported their existing efforts to navigate regulatory systems. This project elevated a more coordinated and poignant conversation about a number of relevant topics – riparian corridors, water resources, agriculture land preservation, orchard permits/fees, and the value-based complexities that frustrate the day-to-day operations of specialty crop growers. (Attachment A, Regulatory Project).

Projects Supporting Specialty Crop Viability: Throughout the project, each of the FSAs had several ongoing committees and projects in place that benefit specialty crop producers/viability throughout the state. The San Mateo, Ventura, Santa Barbara, Santa Clara, and Sonoma FSAs/Agriculture Futures Alliances all established Agriculture Viability and or/Land Use Committees whose work focuses on issues including agriculture land mitigation policies, agriculture land preservation and availability, regulatory coordination, cross-sector partnerships and more. The Sonoma, Fresno, San Mateo, Ventura and San Diego groups all established Farm to School/Institution, Agriculture Education or Local Procurement Committees.

Promotion and Education of Specialty Crops: The project generated significant media coverage and educational awareness for specialty crop agriculture (through the Alliance transition). This awareness and coverage adds accomplishments to the project in the first grant year (October 2012 – October 2013) of placing twenty stories or television pieces covering Alliance successes and specialty crop agriculture. In addition, four major publications outlining agriculture challenges and recommended solutions were produced (Appendix C includes a compiled list of media and publications from each reporting period/year).

Evaluation: Each FSA completed two evaluations per year. AIN dedicated a twenty to thirty minute period of each mid-year meeting agenda to the review: what's working, where their group could do better, and accomplishments achieved (oral evaluations). Anonymous, online surveys were completed each year - results were compiled, and feedback was provided to FSAs and AIN staff.

No project funds were used to promote non specialty crops. The Specialty Crop Block Grant funds 30% of the Alliance Program. While some non-Specialty Crops producers may benefit from program activities, those benefits and portions of those activities were paid for by the other sources of funding for the program: Columbia Foundation, California Endowment, Cliff Bar Family Foundation, San Mateo Health System, Sonoma County Department of Health Services, Alliance member organizations, AIN General Funds. The Producer Advisory Council guided and contributed to each project. While the vast majority of producers serving as members of Alliances are specialty crop growers, and the target of FSA program activities is to benefit specialty crop interests, the structure of the multi-stakeholder model and the food system-level approach (key features of the Alliance program) means that it can be difficult to segregate the beneficiaries of these activities as solely specialty crops and non-specialty crops because some of these activities will benefit both.

The most established agriculture support organizations participate in the Alliance program (e.g., Farm Bureaus, University of California Cooperative Extension, Community Alliance with Family Farmers, agriculture land trusts, and Agricultural Commissioners) alongside specialty crop producers and these organizations represent a multitude of growers. Therefore, while the intended target of program activities is to benefit specialty crop producers, it is inevitable that some non-specialty crop producers will also benefit from these activities, but certainly far less than the 70% non-specialty crop Block Grant Program funding share of the program.

Project partners are the foundation of the Alliance program. Most are represented by anywhere from fifteen to twenty organizations, and the full Network included more than fifty different producers, government agencies, non-profits, and local businesses. Almost every Alliance's boasts members from some of the most prominent entities and organizations who support specialty crop growers, including the Farm Bureau, Agriculture Commissioners, University of California Cooperative Extension, and of course, the farmers themselves. FSA members commit to regular attendance and serious participation in the FSA processes. They volunteer thirty to three-hundred hours each per year and many contribute financially. In addition to meeting attendance, partners do research and conduct needs assessments, scope and plan projects, conduct outreach to other allies, write op-eds, letters, educational materials, and grant proposals supporting FSA projects; organize and produce forums and events. Many partners have offices and/or personnel throughout the state which allows them to be represented in multiple counties. Many Alliances have developed strong partnerships with local universities and educational institutions, and have engaged local civic leaders in their work and in key initiatives. Specialty Crop Block Grant funds provided for the design and facilitation of Alliance meetings, and the development and implementation of activities that targeted project goals. Specialty Crop Block Grant funds were utilized in support of approved Alliance communications and media outreach. Other activities listed are examples of work the Alliance members completed as volunteers of their coalition and were not supported with Specialty Crop Block Grant funds.

These partnerships provide the FSAs with great resources, credibility, and a base of knowledge and expertise that can be referred to as they begin to address issues in their local food and agricultural systems.

Goals and Outcomes Achieved

The main goal of this project was to enhance public understanding of and relationship to specialty crop producers in the eight existing counties (and two new counties) served by FSAs as well as up to three other food system collaboratives. By re-focusing the project in 2014, significant progress toward project outcomes continued to be made, and accomplishments met and exceeded the overall project goals. By restructuring the FSA program to foster leadership and self-management, FSAs have been prepared to remain effective, financially sustainable groups capable of self-promotion and local action.

The Alliance transition enabled AIN to develop and offer a host of tools and resources to improve coalition operations and help develop the skills needed for specialty crop leaders to work together and achieve mutual food system goals – Collaborative Leadership Training, Alliance Toolkit, Salon Series, group assessment tool, and abbreviated launch protocol. The transition enabled the FSA Network plus two non-Alliance groups to become effective, long-term agents for specialty crop market enhancement with improved abilities to address problems facing their groups and overall food industries.

The Producer Advisory Council provided key strategic guidance to ensure the Alliances' highest impact on behalf of specialty crop growers. The PAC's guidance steered the Capacity-Building Services project, resulting in more targeted services to fewer coalitions. The PAC, Salon Series, website transition, and ongoing collaboration with AIN staff enabled the Alliances to communicate county priorities across the state, as well as taking county-level needs of specialty crop growers to state-level audiences (via FSA projects and engagements). The statewide projects, including PAC Produce Engagement Brief, coordinated action (regulatory project), and multiple food system assessments, provided replicable models for communication, collaboration and advocacy on behalf of specialty crop growers and markets.

Ag Innovations Network achieved its target of increasing the competitiveness of specialty crop growers and fostering relationships between specialty crop growers and their communities. Alliances continued ongoing projects and committees supporting specialty crop viability – through strong, working coalitions, forums and community engagement, producing major publications (assessments, action plans and feasibility study), capacity-building services (salons, non-Alliance engagements), etc. The relationships formed between specialty crop growers and the communities in which they operate, while difficult to quantify, have been incredibly powerful throughout the Network. Many formal and informal partnerships have been formed, and the Alliances continue to expand in influence and expertise in the counties they operate and statewide. The Alliances provide a unique forum for crucial dialogue on key topics affecting specialty crop agriculture, and are oftentimes the sole avenue for system-level collaboration. Educating and informing communities across the state was crucial to an elevated awareness and allegiance to specialty crop producers and markets. Through scores of media releases, publications, issue-specific events, community forums, and other social media activities, this project deepened the mutually supportive relationships and partnerships between specialty crop industry and their communities.

Project goal was to increase local FSA and food collaborates' understanding of specialty crop agricultural issues and needs. The benchmark was that FSAs have a long history in promoting the interests of specialty crop agriculture, but urban and newer food collaborative bodies frequently have little or no contact with commercial scale specialty crop agriculture. The target was to create an Advisory Council to help ensure local collaboration's highest impact and conduct at least one statewide campaign or inter-regional organizing effort to utilize the statewide network. The status of this target is complete: The Producer Advisory Council met in year 2013 to 2014 and statewide projects were conducted--PAC's Produce Engagement Brief which included system assessments.

A project goal was to enhance the competitiveness of specialty crop producers in FSA counties. The benchmark was a range of barriers that existed that hindered specialty crop producers in being able to compete in the marketplace. The target was to create at least one program per FSA region that directly benefits specialty crop producers and that can be replicated in other FSA counties. The status of this target is successfully completed; see attachment B.

Another project goal was to deepen the mutual supportive relationships and partnerships between specialty crop industry and their communities. The benchmark was that specialty crop producers should have an expectation that their local communities support them as businesses and as vitally important components of a thriving, healthy local community. The target was a task to promulgate publications, news stories, opinion pieces, issue specific white papers, community forums, websites, social media messaging, and other outreach efforts to educate the public. The status of this target is successfully completed; see attachment C.

The ongoing operation of each Food System Alliance, plus the capacity-building services provided to non-Alliance groups and leaders fostered/enabled long term outcome measures: support for recommendations on land use and environmental health; increased awareness of the value of specialty crops, and the challenges faced by specialty crop producers (land availability, contracting, supply chains, institutional purchasing, marketing, etc.); direct relationships with key agriculture/food system allies (e.g. Public Health Officers, Ag Commissioners, Farm Bureaus, Resource Conservation Districts, UCCE offices, CAFF, etc.); direct engagement in regional efforts throughout the state such as the North Coast Regional Food System Network, the California Food Policy Council (Roots of Change); and elevated capacity to collaborate and work as cohesive, well-informed food system collaboratives.

Beneficiaries

The beneficiaries of this project include specialty crop producers of all scales (organic and commercial), as well as other agricultural stakeholders such as processors/distributors, food access and food security stakeholders, environmental stakeholders, food system workers/labor, public health officials/advocates, local civic officials and community members. The Alliance model ensures that each group, in every county, have a representative membership that includes a member from each of these stakeholder groups as they see fit for their community. Alliance meetings are truly the only forum for specialty crop producers and other agriculture stakeholders to interface, collaborate, identify goals and issues that need to be collectively addressed, and where collective learning and trust building occurs. There are 45,646 specialty crop farms in California (USDA National Agricultural Statistics Services, 2012 Census of Agriculture, Specialty Crops) that potentially benefit from the results of this project, particularly if FSAs are established in other regions.

Agriculture and food system and organizations benefitting from the FSA Network, Transition and Capacity-Building Services projects: 58 agriculture and food related organizations.

California Food Policy Council (25 coalitions), Farm Bureaus, Agriculture Commissioner's Offices, Environmental Health Departments, California Farmlink, Greenbelt Alliance, University of California Cooperative Extension, United States Department of Agriculture, Community Alliance with Family Farmers, Food Banks, Resource Conservation Districts, Public Health Departments, Mendocino County Food Policy Council, Santa Barbara Food Alliance.

Sonoma County (12): Sonoma County, Sonoma Land Trust, Sonoma County Agriculture Preservation & Open Space District, Sebastopol Farmers Market, Petaluma Bounty, Singing Frogs Farm, FEED Sonoma, Community Garden Network, Spiral Foods Cooperative, Shelton's Market, Sonoma County Go Local, and The Farmers Guild.

Contra Costa County (4): Brentwood Agricultural Land Trust, Pacific Coast Farmers Market Association, First Generation Farmers, and CC Department of Health Services.

San Diego County (9): Community Health Improvement Partners, Olivewood Gardens, Farmers Market Association, San Diego State University, Environmental Health Coalition, Network for a Healthy California, North County Community Services, Peoples Produce Project, and Leah's Pantry.

Fresno County (9): Kristina's Natural Ranch, Farmers Market, Fresno Farm Grown Program, Fresno Economic Development Cluster, California Pomegranate Company, OLAM, Sweet Home Farm, California Women for Agriculture, and King & Gardiner Farms.

San Mateo County (9): Miramar Farm, Farmingo, San Mateo Beekeepers Guild, Revolution Foods, Pie Ranch, Fresh Point, Peninsula Open Space Trust, Slow Food of Northern California, Second Harvest Food Bank, and Coastside Farmers Market.

Santa Barbara County (6): Abbott Ranch, Innovative Produce, California Strawberry Commission, Mesa Vineyard Management, Rancho San Julian, and Grower-Shipper Association.

Santa Clara County (9): Full Circle Farm, The Health Trust, Santa Clara Open Space Authority, Kitchen Table Advisors, Chiala Farms, Santa Clara University Food and Agriculture Institute, Veggielution, Collective Roots, and Valley Verde.

Lessons Learned

Alliance Transition & Capacity-Building Services: By re-focusing the project in 2014, significant progress toward project outcomes was made. The transition was a response to the changing needs of the specialty crop agriculture industry and overall food system improvement. As agriculture and food coalitions multiplied, so did their need for enhanced capacity-building services. Groups were established with bold, ambitious intentions, yet members sought out AIN to help improve their ability to collaborate more effectively.

Alliance Model: The democratic, multi-stakeholder model facilitated the creation of a systems-level plans and productions where community engagement and representativeness served as the foundation for action. Convening voices from across the food system to improve local agricultural economies and outcomes enabled a fuller picture of the problems, needs and opportunities that face the specialty crop industry.

Flexibility: Making change to any system is monumentally complex and requires tremendous effort and the Alliances wrestle with some of the state's most enduring, complex issues of the day. Groups and advocates often call for immediate leaps into "action." The team has learned that "slowing down to speed up" is crucial

– building in the capacity that will enable the group to act in alignment and collaboration will enable a more legitimate, efficient, effective outcome.

Some unexpected findings included: Across each Alliance, the difficulties in leveraging and/or retaining the participation of specialty crop producers remained a consistent feature. AIN identified ways to engage producers and increase participation by scheduling meetings on preferred days and times, hosting meetings on farms, and continuing to employ the expertise of producer/ag support organizations, and featuring specific topics of interest. Remedies for improving farmer attendance and participation began to emerge, though few resources tackling producer engagement were available. The Producer Advisory Council elected to produce an informal brief to share their concerns and learnings with other food system collaboratives. The Producer Engagement Brief was created to feature common challenges and share prospective solutions with other coalitions. This activity was not initially planned, but the recurrent theme of producer engagement highlighted a glaring opportunity to share the knowledge from and throughout the FSA Network.

Project team has observed a growing trend; food system coalition members regularly highlight ongoing difficulties in leveraging and/or retaining the agricultural producer voice in their ongoing work, particularly in more urban-focused groups. Why is inclusion of specialty crop producers crucial to food system planning and action? The PAC and Alliance Network leaders offered numerous suggestions throughout three primary sections: Meeting structure, meeting content, and topics of interest.

Additional Information

See Attachments.

USDA Project No.: 2	Project Title: Water Use Efficiency Education for San Joaquin Valley Specialty Crops	
Grant Recipient: California State University Fresno Foundation	**Grant Agreement No.:** SCB12002	**Date Submitted:** December 2015
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Project Summary

Due to the ongoing water crisis in California, new legislation and adjudication on water deliveries has had a negative impact on specialty crop production. Studies on agricultural water use indicate that growers in the San Joaquin Valley faced significant changes in water supplies through reduced exports of delta water, dropping water tables, and the loss of surface irrigation water supplies. Furthermore, water allocations for agriculture have become less dependable, lower quality, more regulated and/or more expensive. To help alleviate the consequences of unpredictable water supplies, specialty crop growers must do the following: keep abreast of new innovative technologies/practices, be aware of the latest governmental regulations, and be prepared to make informed decisions that will help them stay competitive in a global market.

The project's main objective was to educate specialty crop growers in the San Joaquin Valley on new laws, reporting requirements, and regulations, as well as tips on how to effectively deliver adequate and good quality irrigation water to growers' crops. Seminars targeted a range of specialty crop commodity groups, including grapes, almonds, tomatoes, pistachios, and citrus. Other specialty crop growers were encouraged to attend, particularly when seminars focused on legislative issues. When requested by audience members, Spanish translations of printed documents and lectures were supplied. In addition to classroom lectures, the California State University, Fresno (CSU Fresno) Center for Irrigation Technology's (CIT) Mobile Education Center (MEC) was utilized with hands-on irrigation system demonstrations and field trips that provided a complete 'learning by doing' experience that has been proven effective with growers. A practical approach was used to supply specialty crop growers with a basic understanding of regulations and irrigation innovations.

California is currently experiencing a three-year drought that has caused more than $1.5 billion dollars in revenue loss. The central San Joaquin Valley has been one of the hardest hit areas with the drought causing more than 428,000 acres to be fallowed, resulting in the loss of roughly 17,100 seasonal and part-time jobs that may never return. Additionally, the impacts of the drought are expected to continue into the coming years as Californians continue to drill new wells and pump from underground sources. These water resources are expected to become less reliable, more expensive, and of lower quality. Thus, it is important that growers learn what is available in order to become more efficient with water use. The San Joaquin Valley is home to more than 300 agricultural commodities and specialty crops constitute the vast majority of the planted acreage. There is a move to specialty crops by many growers who have found better profitability potential with these types of crops. New technologies available to maximize water use efficiency will help farmers maintain their existing and developing acreage.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

The activities and tasks performed during the grant period were as follows:

1. Organize staff assignments and responsibilities – The Principal Investigators (PI) identified key personnel who would be required to complete the project. This included personnel to help develop the curriculum and organize and promote the seminars. Additionally, CIT staff identified and involved key stakeholders garnering support and feedback from them.

2. Write specific specialty crop irrigation curriculum; set up web site, printed materials, and demonstration equipment – Project staff identified topics and developed general material that have been utilized throughout the project. "Water Use Efficiency for the San Joaquin Valley Specialty Crop Program" is a 23-page booklet that is the cornerstone of the educational effort. The booklet is one part of the packet of materials distributed to each seminar attendee covering topics such as managing and improving irrigation; irrigation scheduling; equipment maintenance; and the water/energy nexus. A copy is attached in Appendix A. Additional materials were developed on a per-event basis since each seminar was tailored to different aspects of improving water use efficiency for targeted specialty crops or attendees. These materials were developed and produced as needed just prior to the events.

3. Marketing and promotion with commodity groups, agricultural organizations, universities, media, and government agencies – CIT staff engaged the community through local radio, news publications and media outlets. For example, the PI and Co-PI were on local Punjabi and Hmong radio stations to promote water use efficiency. Additionally, the staff attended and had outreach events at different specialty crop grower meetings.

4. Seminars #1-#5 – Finalized preparations including schedules, speakers, equipment and curriculum. Set up web site and office phone registration (800) number CIT already has in place. Prepared printed materials and handouts; evaluations; pre- and post-seminar surveys; collated survey and evaluation results. The first five events were held in the spring of 2013 at various locations around the San Joaquin Valley. CIT utilized the Mobile Education Center (MEC) at different farm locations to provide an interactive learning setting. Additionally, attendees were treated to on-farm tours, demonstrations, and discussions about different grower practices and technology use.

5. Seminars #6-#11 – Incorporating feedback from surveys and evaluations, finalized preparations including schedule, speakers, equipment and curriculum; web site calendar. Conducted Seminars #6-11 between Summer/Fall/Winter 2013 and Winter 2014. Prepared printed materials and handouts; evaluations; pre- and post-seminar surveys; collated surveys and evaluation results. Additionally, follow up surveys were sent out to attendees to garner any changes in behavior as a result of attending one of the seminars.

   Seminars #6-#11 were produced primarily on the CSU Fresno campus. CIT staff utilized the University Agricultural Laboratory (UAL) at CSU Fresno for demonstration purposes. Different blocks of almonds, pistachios, stone fruit, grapes, and citrus were used as backdrops for the topics. The topics ranged from irrigation distribution uniformity (DU) to emerging technologies being used on different specialty crop commodities.

6. Seminars #12-#15 – Using feedback from surveys and evaluations, finalized preparations including schedule, speakers, equipment and curriculum; web site. Sent brief follow-up survey to attendees to assess operational changes at least six months after seminar attendance. Conducted seminars #12-#15 Spring/Summer/Fall 2014. Prepared printed materials and handouts; evaluations; pre- and post-seminar surveys; collated survey and evaluation results The topics ranged from online irrigation scheduling, drip irrigation, soil moisture sensors and irrigation monitoring on several specialty crops such as almonds, pistachios, vegetable crops and citrus.

7. Seminars #16-#21 – Using feedback from surveys and evaluations, finalized preparations including schedule, speakers, equipment and curriculum; web site. Conducted seminars #16-#21 Fall 2014 to Spring 2015. Prepared printed materials and handouts; evaluations; pre- and post-seminar surveys; collate survey and evaluation results. The events covered topics such as pistachios, almonds, and vegetable crops. Additionally, irrigation monitoring systems were demonstrated on different specialty crop commodities. On the vegetable crops a soil additive was discussed to demonstrate soil moisture containment and sustainability. Follow up surveys were sent out for events #12-#15.

8. Seminars #22-#24 – Using feedback from surveys and evaluations, finalized preparations including schedule, speakers, equipment and curriculum; web site. Sent brief follow-up survey to attendees to assess operational changes at least six months after seminar attendance. Conducted seminars #22-#24 Spring 2015. Prepared printed materials and handouts; evaluations; pre- and post-seminar surveys; collated survey and evaluation results. The topics for seminars #22-#24 ranged from drip irrigation DU testing, online irrigation scheduling and soil moisture sensors on various specialty crops. Final follow up surveys were sent in May to collect feedback.

9. Seminar #25 – An additional event was added in June, 2015. This well-attended full-day seminar focused on different technologies and management strategies that can assist specialty crop growers especially in the major drought conditions facing the San Joaquin Valley. Speakers from seminars #1 to #24 were invited back to make presentations. A field tour and demonstration was also part of the event.

To ensure specialty crop growers benefitted from this program, CIT staff concentrated on working with specialty crop marketing organizations and associations. CIT partnered with these groups to organize, plan, and invite members and employees to attend the seminars and participate in the program. The activities focused on crops such as almonds, grapes, olives, stone fruit, citrus, pistachios, and tomatoes. CIT worked with the different specialty crop commodity groups by contacting their marketing order or appropriate grower groups for mailing lists or to directly promote the upcoming seminars to members. CIT staff then tailored the seminars to address specific concerns and needs of these growers. The focus of the seminars was regionalized water issues that incorporated pertinent, timely research and studies, including work being conducted by CIT on the UAL at CSU Fresno on some of the latest technologies and irrigation management strategies for vegetables, citrus, almonds, olives, stone fruit, and pistachios. Each seminar focused on a specific subject geared towards specialty crops.

CIT staff worked with the USDA National Resource Conservation Service (NRCS) office out of Fresno, Modesto and Bakersfield to promote events to growers. The NRCS promoted and provided workshop location space for events. In addition, the NRCS also provided speakers and targeted outreach towards hard-to-reach growers, such as Southeast Asian growers and Hispanic growers.

CIT teamed up with the Almond Board, Fresno Farm Bureau, California Citrus Mutual, Tomato Growers Association and the American Pistachio Board (based in Fresno) to promote events to their constituents. These groups promoted towards their specific commodity growers.

One of CIT's activities was to install and utilize some the latest water management technologies on the UAL at CSU Fresno. These installations were donated and used for conducting field demonstrations and targeted lectures that became valuable components of many of the seminars. Some of the companies involved in these installations included: Pure Sense, McCrometer, WiseConn, Hortau, Observant, Mazzei Injectors, California Department of Water Resources (DWR), Bennett and Bennett, Toro, Netafim, Jain, AgH2O, H2O Optimizer, Irrigation Matters, Sentek, Dynamax, mOasis, and many other guest speakers and presenters covering irrigation technologies.

Goals and Outcomes Achieved

The 25 seminars were produced to benefit specialty crop growers and farm operations staff by allowing access to the most current information on pending state water policy such as SBX7-7, new technologies, and irrigation management strategies. This information was intended to help growers improve water use efficiency and reduce energy use during what has now become an unprecedented drought. Increasing water use efficiency can allow for more production with less water. By maximizing water resources, specialty crop growers are helping to sustain California's economy and keep rural communities healthy.

The goal of this program was to increase the knowledge of over 1,000 specialty crop growers and irrigation professionals attending seminars that provide the latest information on government and legislative issues, new innovations and efficient irrigation practices. CIT staff intended to increase the knowledge and skills of attendees by promoting a "learn by doing" seminar series with live on-farm interactive demonstrations located throughout the San Joaquin Valley from Kern County in the south to San Joaquin County in the north. USDA NRCS, CIT, DWR, and many specialty crop grower organizations and individual farms teamed to deliver these educational events. Spanish, Hmong, and Punjabi translation of lectures and written materials were supplied for several events, allowing CIT to reach a wider audience and contact growers who many times are not included or able to attend workshops to increase their awareness of these new developments and technologies.

The following is a list of events produced by the program. The list contains the dates, topic, locations, speakers, and number of attendees.

WATER USE EFFICIENCY FOR SPECIALTY CROPS SEMINAR LIST 2013-2015						
Event No.	**Date**	**Topic**	**Location**	**Curriculum**	**Speakers/ Partners**	**Attendance**
1	8-Apr-13	Water Use Efficiency: Pumps and Irrigation Scheduling (Punjabi)	Sihota Farms: Selma	Pumps, Irrigation System and WUE	Dave Durham- NRCS, Sam Vang- NRCS, Bill Green, Kaomine Vang	17
2	23-May-13	WATERIGHT for Specialty Crops	CSU Fresno Computer Lab, Agriculture Building	Wateright	Kaomine Vang, Bill Green	23
3	22-May-13	Water Use Efficiency on South East Asian Crops (Hmong)	Cherta Farms: Del Rey	Pumps, Irrigation System and WUE	Sam Vang- NRCS , Bill Green, Kaomine Vang	15
4	6-Jun-13	Water Use Efficiency with AirJection Technology on Processing Tomatoes	CIT Tomato test plot – CSU Fresno, CIT Conference Room	Venturi air injection systems	Angelo Mazzei- Mazzei Injectors, Dave Goorahoo-Professor at CSU Fresno, Bill Green, Kaomine Vang	35

WATER USE EFFICIENCY FOR SPECIALTY CROPS SEMINAR LIST 2013-2015 (continued)						
Event No.	**Date**	**Topic**	**Location**	**Curriculum**	**Speakers/ Partners**	**Attendance**
5	23-Jul-13	Water Use Efficiency with Almonds: Irrigation Monitoring Systems	CSU Fresno Farm Almonds, CIT Conference Room	Soil Moisture Monitoring and Irrigation Scheduling, DU	David Jamison Pure Sense, Bill Green, Kaomine Vang	60
6	22-Aug-13	WUE for Citrus- Distribution Uniformity (DU)	CSU Fresno Farm Citrus, CIT Conference Room	Irrigation System, DU and WUE	Bill Green, Kaomine Vang	45
7	24-Oct-13	Water Use Efficiency with Stone Fruits	CSU Fresno Farm Peaches, Nectarines, CIT Conference Room	Soil Moisture Monitoring and Irrigation Scheduling, DU	David Jamison Pure Sense, Bill Green, Kaomine Vang	35
8	21-Nov-13	Water Use Efficiency for Pistachios	CSU Fresno Farm Pistachios, CIT Conference Room	DU and Irrigation Scheduling, system performance	Bill Green, Kaomine Vang	60
9	4-Dec-13	Water Use Efficiency for Grapes	CSU Fresno Farm Grapes, CIT Conference Room	Drip system maintenance and DU	Dean Best- Bennett and Bennett, Inge Bisconer-Toro	40
10	15-Jan-14	Wateright Irrigation Scheduling for Almonds and Grapes	CSU Fresno Irrigation Classroom	Wateright	Kaomine Vang, Bill Green	20
11	23-Jan-14	Soil Moisture Monitoring Systems on Olives	CSU Fresno Farm Olives, CIT Conference Room	Soil Moisture Monitoring and Irrigation Scheduling, DU	Guillermo Valenzuela-Wiseconn, Bill Green, Kaomine Vang	35
12	10-Apr-14	Water Use Efficiency on Drip for Specialty Crops	Kern Ag Pavilion, Bakersfield	Pumps, Irrigation System and WUE	Bill Green	40
13	18-Jun-14	Water Use Efficiency on Almonds	CSU Fresno Farm Almonds, CIT Conference Room	Soil Moisture Monitoring and Irrigation Scheduling, DU	David Jamison Pure Sense, Bill Green, Kaomine Vang	55
14	14-Aug-14	Pistachios – Irrigation Monitoring System	CSU Fresno Farm Pistachios, CIT Conference Room	Irrigation System Monitoring from Reservoir to Drip	Phil Reh- Observant, Other Observant speakers, Bill Green	45
15	7-Oct-14	WATERIGHT Irrigation Scheduling for Tree Crops and Vegetables	CSU Fresno Vegetables and Citrus	Wateright	Kaomine Vang, Bill Green	24
16	16-Oct-14	Dynamax Sensors in Almonds	CSU Fresno Farm Almonds, CIT Conference Room	Almond Stress Sap Flow sensors, irrigation scheduling, Pressure Bombs	Mike van Bavel- Dynamax, Bill Green, Kaomine Vang	65
17	30-Oct-14	mOasis- Polymers in Vegetable Crops	CSU Fresno Farm CIT Test Plot, CIT Conference Room	Using Polymers to retain Soil Moisture in Vegetable Crops	Bardia Dehghanmanshadi-Moasis, Dave Goorahoo, CSU Fresno, Kaomine Vang	35
18	11-Dec-14	WUE and Pumps – Spanish	Bolthouse Farms: Bakersfield	Pumps, Irrigation System and WUE Row Crops (Spanish)	Bill Green, Oscar Torres	30
19	29-Jan-15	Water Use Efficiency on SE Asian Crop	CSU Fresno Farm Citrus, CIT Conference Room	Pumps for Row Crops and Citrus- DU (Hmong)	Sam Vang- NRCS , Bill Green, Kaomine Vang	18
20	26-Feb-15	Water Use Efficiency Specialty Crop Tree Fruit (Spanish)	CSU Fresno Farm Peaches, CIT Conference Room	Pumps, Irrigation System Maintenance and Performance (Spanish)	Bill Green, Kaomine Vang,	25
21	12-Mar-15	WUE through soil mapping, variable rate irrigation, drones for Nut Crops	CSU Fresno, CIT Conference Room	Mapping, Drones, Variable Rate Irrigation Systems	Brian Bassett- H2O Optimizer, Bill Green	35
22	2-Apr-15	WATERIGHT for Specialty Crops	Modesto, Double Tree Inn	Wateright	Kaomine Vang, Bill Green	15
23	21-Apr-15	WUE for Almonds- DU	CSU Fresno Farm Almonds, CIT Conference Room	DU Testing for Proper Almond Drip Performance	Kaomine Vang, Bill Green, Dr. Florence Cassel-Sharma	23
24	21-May-15	WUE for Citrus using Tensiometers	CSU Fresno Farm Citrus, CIT Conference Room	Tensiometers on Citrus for Soil Moisture	Joe Wiegand- Hortau, Bill Green, Kaomine Vang	35

WATER USE EFFICIENCY FOR SPECIALTY CROPS SEMINAR LIST 2013-2015 (continued)						
Event No.	**Date**	**Topic**	**Location**	**Curriculum**	**Speakers/ Partners**	**Attendance**
25	18-Jun-15	WUE for Specialty Crops Review	CSU Fresno- Peters Business	WUE for Specialty Crops Recap and Review	Various	80
					TOTAL ATTENDANCE	**910**

Project staff hope that seminar attendees will irrigate more efficiently in the long-run. CIT staff attempted to measure changes in behavior as a result of attending a seminar. CIT had some success in getting regular feedback from attendees. The response rate on pre- and post-seminar surveys that attendees complete at the events has been high. Low response rates on follow-up surveys has been a chronic issue, so the sample size is relatively small. However, based on the sample size, it can be inferred that attendance to one of the seminars affected the grower/attendees' irrigation practices. This could lead to a long-term change in water use thus reducing and restricting on farm water use. Raising awareness of new innovations and technologies within specialty crop irrigation systems and irrigation scheduling will no doubt continue to move forward the concept of water use efficiency. Greater production on a crop per drop basis will be the outcome.

CIT completed 25 of 25 seminars. The events reached 910 attendees, just 90 attendees shy of the 1,000 the project intended to reach. Included in these events, CIT conducted several workshops geared towards underrepresented minority farmers such as the Southeast Asian (Hmong, Laotian, Vietnamese), South Asian (Punjabi), and Hispanic growers. These hard-to-reach groups were targeted and successful collaboration with the USDA NRCS and other San Joaquin Valley based organizations assisted with enhancing the effectiveness of the seminar events for underrepresented minority farmers and farm operations staff. Additional future collaboration should yield even better outcomes for attendance and participation.

The baseline data that has been gathered to date indicates that roughly 50% of seminar attendees did not have prior knowledge of the specific information presented at individual seminars. CIT staff aimed to increase the knowledge of at least 75% of the participants. Of the 910 participants, 90.4% of them indicated that they increased their knowledge. This is based on responses to the pre- and post-seminar surveys collected at each event consisting of five questions specifically tied to curriculum and information delivered at those 25 seminars. Some of the most pertinent, useful, and highly requested subjects were repeated but most of the information presented was new technologies aimed at assisting growers in becoming more efficient with limited water supplies on the specialty crop targeted at each event.

Pre- and post-seminar questionnaires were utilized to measure participant advances in knowledge at each event. These pre- and post-seminar surveys consisted of the same questions at the start of each individual seminar and at the end of each individual seminar. Answers were simple yes/no allowing for an exact measurement of increased knowledge and awareness of the subject matter presented during each event. The target of this program was to provide a measurable increase in the irrigation knowledge (in this case regulatory and efficient irrigation practices) of at least 75% of the participants. In addition, at the end of each event, attendees were requested to participate in a separate seminar evaluation to provide feedback to track seminar effectiveness. Finally, a follow-up survey was sent to participants six months after each seminar to assess any on-farm changes that may have been implemented as a result of the seminar. These were three separate tools which measured seminar effectiveness, as well as change in growers' knowledge and intended implemented changes to irrigation practices and equipment.

The original target was to attain a four out of five cumulative score on the effectiveness of the seminars with a 75% increase of attendee knowledge after seminars and 50% of attendees making some management, technological or on-farm practice changes based on the information from the events. However, the scale was changed to a four-point scale (ranging from 1 to 4) in order to push attendees into making a positive or negative assessment. This was done to prevent attendees from consistently picking the middle of the road score (3) which research has identified as being a problem with a 5-point Likert scale.
Of the 910 attendees, 302 of them were surveyed to evaluate the seminars. The survey data indicates the participants felt that the seminar programs gave them a better understanding of water use efficiency (receiving an average of 3.65 out of 4~91%). The attendees also felt that they understood the material that was covered and the facilities utilized in the program provided a good learning environment. Additionally, the majority of participants felt, based on the information they received at the events, they would attend another event (3.7 out of 4~93%). Most of the on-campus seminars presented at CSU Fresno involved classroom presentations combined with a field trip to the 1,000-acre UAL at CSU Fresno where equipment and new technologies have been installed by participating companies and can be used for live demonstrations. Soil moisture sensors, sap flow sensors, irrigation scheduling, flow meters, irrigation system pressure, system DU, reservoir water elevations, pumps, and variable frequency drives were some of the pieces of equipment highlighted on specific specialty crops.

Beneficiaries

The primary beneficiaries of this project were California specialty crop growers, farmers, farm operations staff, and minority growers. Additional groups that benefited were commodity groups, specific specialty crop marketing orders, and irrigation industry consultants and professionals.

The center reached 910 attendees. These attendees ranged from large-scale farmers to small acreage growers who rent and lease land such as the many Southeast Asian farmers. This program may have a larger effect that is not measurable due to the inability to track how the information provided is being used at the local level.

The information may have caused behavioral and technological changes in growers and their farm operations employees, but accurately assessing this change is challenging. While the return on the follow-up survey was not very good, the data indicates that 87.5% of the respondents made changes on their farms based on the material presented at the seminars. Additionally, 100% of the respondents stated they intended to or already made changes based on the information gained from the seminars. Face-to-face feedback at these events demonstrated a great interest from most attendees to understand and adopt new technologies and management strategies. The drought has hastened the need to adapt to stay in business.

Lessons Learned

While the information provided at each event was valuable and far reaching, it was very difficult to reach growers in the summer months, primarily due to the busy growing season. Timing is critical in conducting agricultural events. Some growers registered to attend and did not show up. CIT conducts many agricultural events and has found that this is not uncommon. No-shows are very often related to the weather, planting, harvesting, or other farm operation and maintenance responsibilities. However, the events did have good attendance in the summer months for several topics such as ones produced about almonds, pistachios, grapes and citrus. This may be because they are high-value crops.

Another issue was the rapid scheduling of events to complete the 25 seminars within the grant period. In some cases, people who signed up via the project's email database were receiving too many invitations and reminders perhaps causing them to ignore or unsubscribe because project staff were contacting them too often. The rapid succession of seminars sometimes caused overlap of registrations. This is an issue for many businesses that oversaturate emails and the result is people deciding to unsubscribe. As a consequence of the drought, more funding has become available to develop educational tools to help farmers become more efficient. The number of seminars and webinars has increased. The primary means to promote these was electronically. Fortunately, CIT staff became aware that this was occurring and used other media outlets and farm organizations to help advertise the upcoming events. This stabilized and even increased the database of email subscribers throughout the grant period.

It was identified that while the NRCS has many programs that can help growers, many growers do not know about them. This is especially true of the hard-to-reach growers. Also, finding and reaching hard-to-reach growers such as the Southeast Asian, South Asian and Hispanic farmers is a challenge. These groups did not utilize nor were they part of any marketing orders or specialty crop boards. Thus, contacting and inviting these growers to seminars was done primarily through word-of-mouth and personal invitation. Additionally, CIT staff worked with different local Hmong and Punjabi radio stations geared primarily towards these groups in hopes of reaching them. It was also identified that the hard-to-reach growers were the ones who might need the most assistance and had the fewest resources.

Moreover, many growers are skeptical of new technologies since they have had prior experience with different technologies and found that some of these were hard to work with, thus making them distrustful of those new irrigation technologies. However, involving an established university organization such as CIT, a third-party entity, encouraged growers to be more attentive towards the ideology behind the technology.

Lastly, it was difficult to garner six-month feedback surveys from participants. Growers simply did not respond to emails and electronic messages consistently.

Based on the data collected from the pre- and post-seminar surveys at the events, roughly 50% of the attendees did not have a good understanding of the topics being presented prior to attending the seminars. After the seminars, 90.4% of the attendees felt they had a better understanding of the topics being presented at the seminars. This post-seminar number was higher than originally anticipated, especially since many of the subjects were similar technology subjects, just different equipment and applications used to measure soil and plant response to irrigation.

According to the six-month follow-up survey, 100% of the respondents stated that they made changes due to the information presented at the seminars. Additionally, 92.9% of the respondents felt the seminars increased their knowledge. Of the respondents, 87.5% indicated that they used the information to make water management changes on their farms. The respondents also indicated that they would like to see more presentations such as these. These results, though limited in number of respondents, were unexpectedly higher than anticipated and show the effectiveness of these seminars.

The project's partners may have an increased customer base and outreach through this project. For instance, the NRCS may have gained more users of their different programs geared for farm improvements. Technical information presented on irrigation technologies also resulted in the adoption of these technologies. Irrigation equipment manufacturers assisted with technology and equipment demonstrations and installations at many of the seminars, donating many of the equipment installations and staff time.

CIT staff were unable to reach the 1,000 attendees targeted; however, 910 attendees were reached over 24 months. Due to the drought, there was a saturation of events focused on drought relief and water use. Outreach efforts needed to be changed to include drought relief as part of the water use efficiency seminars. On average, about one quarter of pre-registrants did not attend even after reminders of their registration were sent. Walk-ins on the seminar days offset about a third of the no show deficit. If a higher percentage of registered people would have attended, the number originally targeted of 1,000 would be easily attainable. There was limited space for most events, so it is assumed some of these people just sign up in case they could attend and didn't want to lose a spot to limited registration space.

Moreover, the return on the follow up surveys was lower than anticipated. This could be due to oversaturation of surveys online and growers deleting the constant barrage of various surveys. Still, enough were collected to point to the success of the Water Use Efficiency for Specialty Crops seminars.

Additional Information

Information in regards to presentations and handouts can be found at:
https://www.fresnostate.edu/jcast/cit/untitled.html

Attachment 1: Water Use Efficiency for the San Joaquin Valley Specialty Crop Program

USDA Project No.: 3	Project Title: Fresh Farming for the Future at Fairplex: A Specialty Crops Education Project	
Grant Recipient: The Learning Centers at Fairplex	**Grant Agreement No.:** SCB12003	**Date Submitted:** December 2014
Recipient Contact: Elin. R. Dowd	**Telephone:** (909) 865-4208	**Email:** elin.dowd@fairplex.com

Project Summary

This program site is located in the low-income, disadvantaged community of Pomona, California, which is in the Los Angeles County. In this region, 21% of children in grades 5, 7, and 9 are obese, 24% have hypertension, 32% with high cholesterol, and 16% with diabetes or heart problems. Experts recommend that one effective way to combat this serious issue is to increase accessibility to healthy foods, particularly fruits and vegetables; however, Pomona has extremely limited access to and little promotion of fresh specialty crops. Furthermore, multiple studies showed that individuals' active involvement in plating their own fruits and vegetables will lead to greater crop consumption. The purpose of The Learning Center at Fairplex (TLC) was to provide relevant solutions to the healthy well-being of Southern Californians by increasing the familiarity and exposure of over one-hundred different California specialty crops, as well as educating 900,000 community members about these crops through expansion of the current-one-third acre agriculture space to a three-acre organic farm; and providing Fair-time programming, early childhood education, agricultural career education, community plots, and year-round promotion with local organizations to community members. This project can also serve as a great model for other fairs throughout the state.

The timeliness and implementation of this project encouraged awareness about health problem statistics in Pomona, California; as well as provided education on healthier eating, and exposure to California specialty crops, which provided immediate and long term positive health benefits. By completing this project in time for the 2014 Los Angeles County Fair, TLC was able to tell the story of 'The Farm' expansion, the importance of healthy eating, and the continued education on California specialty crops. Education about specialty crops was an integral component of the Fair-Kids Field Trip Farm curriculum. TLC offered community classes with lessons: Growing from the Seed (in English and Spanish languages), Growing from Cuttings, Welcome to the Herb Garden, Why Do Tomatoes Not Grow, and Grafting Tomatoes. Each class was held on the farm and presented California specialty crops.

This project did not build on a previously Specialty Crop Block Grant Program (SCBGP) funded project or another federal or state grant funded program.

Project Approach

The transformation of the previous .75 acre garden to a four acre (compared to the original goal of three acres) farm was successful and was called "The Farm" at Fairplex. The Farm included the installation of raised beds and planting areas. The Farm features include ideas for how to creatively plant specialty crops in vertical gardens, as well as traditional plots. The completion of The Farm included enhancements to the educational programs during the 2014 Los Angeles County Fair. Relocating the entry to The Farm allowed a portion of the 1.3 million guests to enter The Farm directly from the most utilized gate on campus, and during the Fairkids program, it was easier for children to walk to The Farm and see the expanded garden. Strategically located in the heart of The Farm, the Farm Kitchen created a selection of flatbread choices as a way to promote the use of California specialty crops. Each flatbread included at least one specialty crop item grown on location. While foods used to bake the flatbread are not specialty crops, project grant funds were not used for the Farm Kitchen or commodities other than specialty crops.

Over one-hundred specialty crop signs were created to correspond to over one-hundred specialty crops that were planted during the grant period by the PD and collaborating horticulturist. Fair-time activities were also created and implemented for both 2013 and 2014 fairs. This included several new and returning exhibits highlighting California specialty crops, which was an integral part of the 2013 and 2014 Los Angeles County fair (LACF) educational programs. Some of the fair-time presentations included: A southern California olive oil company who hosted olive oil pressing demonstrations and tastings. The Los Angeles County Bee Keepers Association created the Bee and Honey Exhibit with a live honey bee hive; and taught the guests about the importance of bees, bee pollination, and where honey comes from. The Farmer for Day event presented guests with opportunities to plant seeds, harvest fruits, and vegetables, and had an idea of what it is like being a farmer. This was also a fantastic place for children to come and experience what life is really like on a farm, and learn how vegetables and fruits are harvested. Children of all ages explored this exhibit; it encouraged them to follow their crop from seedling to harvesting, and then to the market where they received "imitation dollars" to purchase crops from a fictional market. Educated staff had informational stands available to answer questions and explain the importance of specialty crops. After experiencing the interactive exhibit, guests were given specialty crop seed packets to take home; this reinforced the lessons learned during this exhibit.

Gathering and Evaluating Fair-time programming results:
Farm docents were on hand for both the 2013 and 2014 Fair events and administered the survey with the following results: 94.2% of Fair guests participating in the survey reported that they learned something new from the signage surrounding the different specialty crops, compared to 90.4% during the 2013 Fair; 72.4% of Fair guests participating in the survey reported that they were likely or very likely eat more specialty crops as a result of visiting the farm; over one-hundred specialty crops growing in the garden were listed for Fair guests to select and identify. The most frequently identified crops were: Peppers (67%), apples (58%), kiwi (57%), mint (54%), tomatoes (50%), artichoke (49%), squash (49%), carrots (45%), lettuce (44%), cucumber (43%), and fig and okra (39%). The above specialty crops were the top twelve most frequently identified crops in 2014; whereas in 2013, less were identified. This shows positive trends towards enhancing the knowledge of specialty crops.

LACF marketing team administered their own survey and asked questions specific to the Farm; 2013 and 2014 results are as follows: In 2014, rating of satisfaction of fair features was 4.19 out of 5, compared to 4.16 out of 5 in 2013; in 2014, 36.1% of visitors ranked The Farm as the second biggest influence for coming to the Fairplex, compared to year 2013, when 29.5% of visitors ranked The Farm as the fourth reason for the visitation. In 2014, 61.3% of the visitors said they will visit The Farm first before visiting other stands at Fairplex, compared to 2013, where 39.6% of the visitors ranked The Farm as the third place to stop by after having visited other stands at Fairplex.

Recruitment of students, implementation, and evaluation of Career and Technical Education Center (CTEC) horticulture classes: Since the beginning of the grant in October of 2012 through March of 2014, CTEC Urban Gardening course enrolled ninety-three students into the horticulture classes. Between April and September of 2014, an additional thirty-eight students were enrolled, bringing the total number of students served to one-hundred and thirty-one.

Planning, implementing, and evaluating activities with expanded garden for students at The Child Development Center (CDC): At the beginning of 2013, the CDC integrated the Garden curriculum into each child's learning experience at the Fairplex Farm. The students learned about the specialty crops through the integration of crops into their weekly lessons, and by active engagement in planting, nurturing the garden, harvesting, and eating the crops. Furthermore, CDC at Fairplex implemented a variety of new activities in the following year to engage young learners in the education of specialty crops and the process of harvesting those crops. The preschool and kindergarten classes were assigned a row of crops to tend to; the children were heavily involved in the process of caring for the crops, which included from planting seeds, turning dirt, and watering to harvesting. When the time came to eat those crops, students learned what each item was and how to prepare it. As a result of their hands-on engagement, the children were significantly more willing to try a wide variety of specialty crops due to their established sense of ownership of these crops. So far, the highest yielding crop and the most in demand to take home was kale. Some of the specialty crops growing at the CDC included: Cauliflower, beets, cabbage, carrots, broccoli, snap peas, radish, cilantro, parsley, eggplant, onion, cucumber, oregano, and chives. Additionally, the kindergarten class began utilizing flash cards with pictures of specialty crops on them to test the knowledge of being able to identify what type of plant was shown. The visual recognition of different crops growing in their garden was very high. Between the preschool and kindergartener students, they have demonstrated 67% recognition of specialty crops. They have also been reading books about the planting and harvesting processes of crops; as well as, focusing their cooking activities around specialty crop vegetables and fruits grown in their garden.

Integrating crops into the facility menus and lead community events: The main focus was highlighting the use of specialty crops in menus, and The Farm at Fairplex continues to be a preferred source of specialty crops produce for banquets, catering and restaurant businesses. McKinley's Restaurant procures approximately 15% of all of its current produce from The Farm. The Sheraton Fairplex banquet and catering operation procures approximately 5% of its produce from The Farm. This was a great opportunity to promote specialty crops. Grant funds were not used to promote any other commodities other than California specialty crops.

During the 2014 Fair, twenty farm tours were conducted, compromising one-hundred and thirty-four individuals: 80% of the community (local businesses, Indonesian community leaders; local and county community leaders, and neighbors within the city limits); 10% schools; and 5% of foundations.

Planning and implementing cross-promotional opportunities with Cal Poly Pomona and Mount San Antonio College: In October 2013, under the direction of the Fairplex horticulturist and the PD, and in partnership with Cal Poly Pomona Agriculture School, students, faculty, thirty community volunteers, and Fairplex employees gathered at Fairplex and Cal Poly Pomona olive orchards for the first olive harvest where several hundred pounds of olives were picked. The olives were delivered to a press at Figueroa Farms in Central California for pressing and bottling. From this harvest, fifty-eight cases of two-hundred milliliter bottles, and seventy gallon-size bottles were packaged; and are currently used in the restaurant and at Table to Farm dinners to promote specialty crops and establish new partnerships.

Planning, promoting, and offering biannual trainings in community garden/crop programs and organizing community crop schedules for families and groups: Community outreach, information, and education were established in various ways. The goal was to expose as many people as possible to California specialty crops. The Farm experience created a great opportunity to speak about the garden and the specialty crops that were grown there; as well as educate visitors how to take care of these crops through water conservation techniques, organic fertilizers, production scheduling, and how to deal with bug infestation. Additionally, team members conducted outreach activities to various institutions and civic groups, providing cultural growing information on California specialty crops.

Los Angeles County Fair Association provided match-in-kind funds to TLC. University of La Verne has supported the ongoing collaboration with TLC to offer student internships in The Farm, and classes to learn about the California specialty crop production. Mt. San Antonio College provided Adult Education Gardening Program partnership on the Mt. San Antonio College campus. Pomona Unified School District was a partner in helping set up the field trip program. Los Angeles County Department of Public Works provided educational resource on sustainable gardening habits. Los Angeles County Bee Keepers Association was a fair partner in creating awareness to the value of bees in pollinating crops and the benefits of honey; and will also be part of a year-round field trip programming. Forty-eighth District Agricultural Association provided additional gardening kits for farm visitors to promote creating specialty crop gardens at home.

An accounting code was created for use exclusively for invoices, purchase orders, and labor costs associated with the project to ensure that all expenses were properly tracked and solely benefited specialty crops. All supplies (seeds, fertilizer, drips, etc.) were coded with the project code, received by the Project Director, and shipped to a separate location at The Farm-in order to ensure the supplies were used solely for specialty crops. Invoices, purchase orders, and labor costs not associated with the project were coded differently and those supplies were shipped to the facilities department, not located near The Farm.

Goals and Outcomes Achieved

Career and Technical Education Center (CTEC):
Under the direction of the Fairplex education manager and instructions by the Career and Technical Education Center (CTEC) teachers, students in the CTEC program worked in The Farm weekly; and regularly planted and harvested various specialty crops. Horticulturist and the instructor worked together to plan activities and learning experiences for the students that incorporated not only the agriculture side of the specialty crops (planting, growing, care), but how the crops can be used in cooking once harvested.

In the period of 2012 through March of 2014, the CTEC Urban Gardening class enrolled ninety three students. An additional thirty-eight students were enrolled, bringing the total number of students served to one-hundred and thirty-one -- far surpassing the target goal of one-hundred students by the end of CTEC's 2014 summer session. This is an increase of 67% from October 2012 – June 2013 school year, where only forty-four students were served. The students enrolled in these classes ranged from grades 10-12, and represented a total of ten local high schools, including five schools from the economically disadvantaged Pomona Unified School District. One-hundred percent of the students who completed the classes received either an A or B grade; thus showing strong mastery and proficiency of the horticulture skills and competencies within the class training plan.

Child Development Center:
The Child Development Center at Fairplex (CDC) integrated the Garden curriculum into each child's learning experience. The students learned about the crops through the integration of crops into their weekly lessons, and by their active engagement in planting, nurturing the garden, and harvesting (and eating) the crops.

Awareness of specialty crops is increasing at the CDC as well. The Kindergarten class began utilizing flash cards with pictures of California specialty crops and asked to identify what type of plant they were shown. The visual recognition of different crops growing in their garden is very high. Between the preschool and Kindergartener students, 67% demonstrated recognition of specialty crops. They have also been reading books about the planting and harvesting processes, as well as focusing their cooking activities around vegetables and fruits grown in their garden. Additionally, each week in the classroom, the students are taught how plants grow through the help of water and sunlight; as well as the detrimental effects of extreme heat, lack of water, and not enough sunshine. Students are better able to process this information by seeing firsthand, for example, seeing water absorbed in the soil to feed the plant. To coincide with the lesson plans, families are offered the opportunity to take some of the harvested crops home with them, which helps strengthen the connection between their efforts, the importance of healthy eating habits, and a stronger appreciation for the crops they care for.

Child Development Center:
The goal was to have 500 preschool students, family members, and teachers from the Child Development Center exposed to California specialty crops during the grant period. This goal was exceeded, 647 students, families, and teachers were impacted. At the beginning of grant year one, the Child Development Center integrated the Garden curriculum into each child's learning experience, impacting both student and teacher. The students learned about the crops through the integration of crops into their weekly lessons and by their active engagement in planting, nurturing the garden, and harvesting, the crops.

Under the direction of the CDC Director and Project Horticulturist, raised beds were created in order to help organize and improve gardening activities with the children. This helps raise and produce the crops in a more eco-friendly way and helps both, the teachers the students, learn the importance of sustainability. The Child Development Center implemented a variety of new activities during the grant period in order to engage young learners in the education of specialty crops and the process of how they grow. The preschool and Kindergarten classes are each assigned a row of crops to tend to and are heavily involved in the process of caring for the crops, from planting seeds, turning dirt, watering and harvesting. The teachers learned this process as well, since they were onsite to assist and oversee their students. When it comes time to eat the crops they harvest, students learn what each item is and if they can eat the crop raw or how to prepare and cook it first. As a result of their hands-on engagement, both children and teachers are significantly more willing to try a wide variety of vegetables due to their established sense of ownership of these edible crops. Breakfast, lunch, and snacks served at the Center have always incorporated fruit and fresh vegetables, but a pre and post survey were not conducted in order to measure an increase or decrease in consumption. Because of all the steps that have been taken at the Child Development Center throughout the duration of the grant period, awareness of specialty crops has increased. Post survey demonstrated that 67% of preschoolers and kindergarteners were able to recognize specialty crops shown on the flash cards. These students began utilizing flash cards with pictures of specialty crops on them and were asked to identify what type of plant they were shown. They have also been reading books about the planting and harvesting process as well as focusing their cooking activities around those vegetables and fruits grown in their school garden. This educational component at the Center has impacted the families as well, especially when students were taking home crops and recipes and engaging in cooking activities at home. Pre-survey was not successful for preschoolers and kindergarteners due to their limited understanding of written pre-survey content; therefore, the expected measurable outcome of measuring results via pre-survey and comparing to post-survey was not fully achieved. Instead, project team decided to use flashcards with specialty crops imagines and hands-on experience in the garden in order to determine the information retained for the post survey. Results showed that 67% of the preschoolers and kindergarteners, who were exposed to flashcard activities and hands-on garden experience, were able to identify the specialty crops on the flashcards.

The Farm Docents:
During the 2014 fair, over nine-hundred and fifty Ambassadors dedicated their efforts to the educational programming of The Farm. As more schools started having gardens, more students related to this area. They wanted to tell the Ambassadors about their school gardens, tell The Farm manager about problems they were having, and asked for solutions. It validated what teachers were doing at their own schools and inspired other educators to start gardens. Each FairKids class member was sent home with a packet of seeds given by agricultural partners. Children were surprised that the Ambassadors encouraged them to gently touch the plants and get more comfortable with the garden. The Farm managers loved to hand the kids a mint leaves and see their surprise when they smelled it.

Guests learned about healthy eating and they could see how some of their favorite foods were grown. In addition, guests saw interesting varieties of food grown that they have never eaten before. Also, on hand were flats of seedlings to show how plants start from seeds and are then transplanted. Since The Farm had over two-hundred varieties of plants, guests were able to observe how to grow their favorite crops; it gave them ideas about what grows best in their local area.

Community Outreach and Partnerships:
In November, 2013, under the direction of the Fairplex education manager and The Learning Centers, a farm cultivation event took place that welcomed thirty community and education leaders to learn about the expansion of this project. The goal was to increase awareness of the coming Fairplex farm expansion, share project plans, and funding programs. An important part of securing continual support for this program is the ability to tell a story to the community and other stakeholders. The following were community outreach and partnership opportunities that took place during this grant period:

On March 4 and 5, 2014, the Fairplex horticulturist met with twelve volunteers and church members from Pomona Baptist Church that were in charge of their community gardens, and presented a slide show on various California specialty crops that were growing at Fairplex. Presentation was followed by questions and solutions on problems growing different variety of tomatoes. Members had an opportunity to stop by the fair and learn how to prestart seedlings in cold frames, and the basics of grafting tomatoes to continue growing heirloom varieties.

On March 31, 2014, Flying Hills Elementary School of El Cajon had first graders visit The Fairplex farm for a presentation class on how to start specialty crops from seeds, how to transplant, and maintain the crops. The Fairplex horticulturist presented to three first grade classes, composed of sixty-two students, three faculty, and two aides. Students were exposed to hands on experience of transplanting specialty crops; they were provided with one-hundred seed packages, mini greenhouses, pots and potting mixes, along with six trays of forty-eight cell unit crops ready for transplant into the garden or to upsize into a 4 inch pot. Plant seeds included: Red leaf lettuce, red romaine lettuce, green butter lettuce, bok choy, and cabbage.

On March, 2014, the President of the California State Board of Food and Agriculture, made a visit to The Farm, toured the campus, and discussed future plans for expansion. Particularly noted were the extensive number of California specialty crops and the diversity of crops growing on the farm.

On April 24, 2014, forty-eight members of Friendship Garden Club at the Covina Women's Club attended a program hosted by the Fairplex horticulturist. The educational members were presented with information on availability of vegetables for the spring gardens and types of seasonal seeds available.

Horticulturist and Farm manager worked with the Forty-Eighth District Agricultural Association for the 2014 Schools' Agriculture and Nutrition Fair held at Fairplex in the month of May, 2014. The Association's mission is to increase the understanding, appreciation, and participation of urban teachers and students in agriculture and nutrition through cooperative involvements of the California agricultural industry, educational institutions, and community partners. Displays of sunflower seeds sprouting were displayed for students to see. Over 4000 take home kits were distributed during the three-day Agriculture and Nutrition Fair to encourage growing sunflowers.

On May 22, 2014, Montrose Garden Society had thirty-two members and guests that attended The Farm. The Farm manager presented a course on the use of efficient drip irrigation to grow specialty crops. The presentation included proper application of water to vegetable row crops, both seeding and transplant, and how to adapt it to smaller home gardens.

On May 13, 14, and 15, 2014, The Fairplex horticulturist worked with five students from the University of LaVerne on efficiency of water application to raised beds for specialty crops, in particular squash, tomatoes, cucumbers, lettuce and beets.

On June 9, 2014, The Fairplex horticulturist conducted tours of the expanding farm to eighty attendees from a conference on technology (Ungerbook Western Users Alliance) about the California specialty crops that were growing. Of specific interest were the twenty-two varieties of mints that were growing; as well as a demonstration on harvesting beets and squash and how easy it is to grow these crops.

On, June 21 and 22, 2014, The Farm manager with a radio personality representative, filmed a 1 to 3 minute video that was broadcasted as part of the Channel 9 "Things Green." Various California specialty crop topics were covered including: Differences between fresh and storage squash; beets – the root versus the green tops – which is the better food value; starting seeds – in cell packs versus direct sowing; and organic fertilizers versus synthetic.

On August 6, 2014, The Pre-Fair Association Dinner for the Los Angeles County Fair Association was held in The Farm. This event, targeted to bring awareness to specialty crops at The Learning Centers at Fairplex, was attended by over one-hundred and sevety-five civic leaders from the Pomona region.

To open the Los Angeles County Fair on August 29, 2014, a ribbon cutting ceremony was performed at The Farm, and it was the highlight of the event, as demonstrated in Fair guests' surveys that showed The Farm was the number one reason why the guests attended the Fair.

From August 29 to September 28, 2014, during the Los Angeles County Fair, five Farm Docents spent over 288 hours assisting Fair guests with their Farm experience. Three of these five docents were current or former students from the Career &Technical Education (CTEC) horticulture classes, so they were able to put their training to practical, real-world use, giving them the opportunity to educate others. Also during the 2014 Fair, twenty eight community classes were offered with approximately eight-hundred and forty attendees; classes focused on California specialty crops and the value of use in home and community gardens.

On September 5, 2014, over thirty high school Counselors, Career Technicians and school Administrators were welcomed for a tour of The Farm, highlighting over one-hundred specialty crops growing on this farm. This event also allowed them to see first-hand what students from their schools experience when they enroll in Urban Farming and Agriculture educational classes offered by CTEC, a program of The Learning Centers at Fairplex.

On September 17, 2014, twenty three students from Bonita High School Culinary/Hospitality class toured California specialty crops at The Farm and reviewed seeding and germination tips for fall crops. Bonita School started their own garden this 2014 winter for 2015 spring harvest. Classes were given to inform the students on how to use four seed-starting growing chambers, planting seeds, and maintaining the crops.

On September 18, 2014 Chef/Restaurateur and The Farm manager took ABC 7 Food & Fitness Coach on a tour of The Farm at Fairplex, and produced a Farm to Table meal showing guests the health benefits of incorporating California specialty crops into their diets. The following specialty crops were featured: Eggplant, squash, striped melon, and micro cucumbers.

On Sept 27, 2014, the horticulturist conducted a tour and spoke with twenty six representatives of the Fairplex neighbors--people from the surrounding community that are impacted by events at The Farm. The tour focused on the development of the new garden area featuring California specialty crops, and various ways crops can be cultivated locally to enhance one's diet.

Under the direction of the Horticulturist and Farm manager, the organization has planted over two-hudnred specialty crops in the newly expanded Farm, with four acres specifically dedicated to plantings of only California specialty crops. The Learning Centers at Fairplex was on target and successfully met project goals; and encouraged awareness and education to 1.3 million guests of over one-hundred specialty crops, compared to initial goal of 900,000 guests.

The following data shows the number of visitors from beginning of the project period to the end:

	(Oct. 2012 – Sept. 2013)	(Oct. 2013 – Sept. 2014)	(Sept to Mar. 2014)
Fair guests	560,000	738,610	1,298,610
CTEC students	49	131	180
CDC students/parents	327	320	647

Community members 88	737	825

Exposure to Specialty Crops:
Increase exposure and awareness to over 100 different California specialty crops and healthy eating to 800,000 Fair guests was achieved with engaging learning experiences, educational signage, and hands-on demonstrations by the end of the grant period. The grant period impacted both the 2013 and 2014 Fair and exceeded the exposure of 800,000 guests, and had 1,298,610 individuals engage in the Farm and learn more about specialty crops. During this project term, 10 Farm Docents spent over 576 hours assisting Fair gusts with their Farm experience. Docents and Ambassadors encouraged Farm visitors to touch the plants as well as read the signage about the specialty crops and ask questions. After the guests went through the Farm, docents were on hand to administer a survey to the guests to measure the impact of their visit and what they learned about specialty crops. Results are as follows: 94.2% of Fair guests participating in the 2014 survey reported that they learned something new from the signage surrounding the different specialty crops. Compared to 90.4% during Fair 2013. 72.4% of Fair guests participating in the 2014 survey reported that they were likely or very likely to eat more specialty crops as a result of visiting the farm at the Fair (24.4% were neither likely or unlikely). The survey results for 2013 were similar. Over 100 specialty crops growing in the garden were listed for Fair guests to identify which crops they saw during their visit. Even though all Fair guests did not identify all the crops listed, 100% of the crops were identified by some segment of the survey population. The survey results for 2013 were similar. The most frequently identified crops were Peppers (67%), Apples (58%), Kiwi (57%), Mint (54%), Tomatoes (50%), Artichoke (49%), Squash (49%), Carrots (45%), Lettuce (44%), Cucumber (43%), and Fig & Okra at (39%). The survey results for 2013 were similar. Of the 1,298,610 guests who visited the Farm, 305,000 were children who came on an educational field trip during the 2013 and 2014 Fair. After each visit, teachers emailed a survey in order to capture information about the Farm and overall educational offerings during their visit. Of the survey's received, 96% reported that the Big Red Barn and Farm was the area they visited most and were exposed to specialty crops. The Farm was reported to be a favorite by teachers who commented on how much their students learned about specialty crops and healthy eating alternatives. Visitors surveyed in The Farm along with many other Fair guests were also sent home with a packet of specialty crop seeds donated from agricultural partners to further enhance their long term exposure to healthy eating beyond their visit to the Farm.

Public Garden Plots:
The initial goal was to have 600 family and community group members plan, plant, maintain and harvest their own plots in the Farm, but due to a facility-wide change in land usage, there was very limited space for community gardening of specialty crops; therefore measurement of success was not fully achieved. In order to remain committed to encouraging the community to maintain their personal garden, even if it wasn't located on the campus, site visits, lectures and hands on learning experiences were provided to 825 community members. A basic visit to a school site from the Horticulturist would involve taking seeds, potting mixes, containers, and growing chambers along with pre-germinated seedlings and transplant sets. The visit included an age appropriate lecture, a hands-on session of planting seeds in the provided containers, transplanting older plants to community plots, and additional onsite consulting services in the garden itself whether the garden was just containers or raised planters.
In addition, community outreach included presentations to civic groups consisting of various programs on seeding or other propagation methods. Community members unable to come on site were given a tour of the garden through photos. The garden contains cost and space effective ways to create gardens in any type of neighborhood. In addition to the lectures and hands on planting, seeds, soil mixtures and germination trays

were given away to those in attendance. Because the community gardens were not planted in the Farm at Fairplex, the weighing of produce was not conducted. Surveys determining impact on meal planning were also not administered.

Lessons Learned

In the beginning of this project, the hope was to improve the educational programs by offering exposure and experience with California specialty crops at The Learning Center at Fairplex. It was not expected that this project would transform the current farm campus and create an environment of learning like none other in this area. Guests that experienced the specialty crop garden were not only inquisitive about crop exhibits, but they were inspired to take what they have learned and duplicate the experience at home or in other parts of the community. The educational courses on specialty crops became one of the main attractions of the Fair. The project team did not anticipate the extraordinary level of excitement that came regarding the specialty crop garden and information about gardening. This experience was a lesson learned for the project team because it proved that with effort and dedication, the achievements could be bigger than original goals.

One unexpected issue encountered during this project was the management of the harvest. Project team had the ability to use majority of the crops in culinary activities or in educational programs; however, project team did not expect the amount of excess crop that was produced and unable to be utilized fast enough. Creating plans to improve the ability to preserve products with healthy processes is an important goal to work on and implement.

Due to a facility-wide change in land usage, the lands available and suitable for public community vegetable gardening were reduced. In order to remain committed to that aspect of the project, the project team continued to involve outside community members and school gardens by helping them develop their own gardens. Site visits, lectures, and hands on learning experiences were provided in order to help establish independent gardens. In addition, community outreach included presentations to civic groups consisting of various programs on seeding or other dissemination methods. Community members that were unable to come on site were given a tour of the Fairplex garden through photos. The garden contains cost and space effective ways to create gardens in any type of neighborhood. In addition to the lectures and hands on planting, seeds, soil mixtures and germination trays were given away to those in attendance.

Despite these minor delays, project team were able to successfully accomplish the outreach/programming goals, and collect responses to the surveys from the 1.3 million guests that attended the 2014 annual Fair, with all projects and demonstrations in place for their learning experience about California specialty crops.

Additional Information

See attachment.

USDA Project No.: 4	**Project Title:** San Joaquin County AgVenture	
Grant Recipient: San Joaquin County	**Grant Agreement No.:** SCB12004	**Date Submitted:** December 2015
Recipient Contact: Krista McCoon	**Telephone:** (209) 402-5734	**Email:** sjcagventure@yahoo.com

Project Summary

Overweight and obesity rates have reached epidemic proportions in San Joaquin County (SJC) at more than 65% (SJC Public Health, 2009). Obesity, particularly childhood obesity, has many health and psychosocial consequences that continue into adulthood, such as Type 2 diabetes, heart disease, stroke, decrease in self-esteem, and depression. Prior to the AgVenture program, there were no programs in SJC that offered agriculture and nutrition education services to students. Additionally, SJC is the sixth most productive agricultural county in California and the nation. With agriculture, the county's largest industry, grossing nearly $3 billion annually, it is vital for students to learn about agriculture and its benefits. Therefore, the AgVenture program served to educate students about nutrition and healthy living by demonstrating the benefits of locally-grown specialty crops.

The program delivered seven third grade AgVenture field trips, in northern, central and southern SJC from November 2012 to November 2014. During these seven events, 1,850 specialty crop farmers, producers, and other volunteers donated their time and expertise to bring educational presentations and displays to 26,000 students from 144 schools. The educational program focused on increasing participant knowledge in the following areas: the importance of SJC specialty crops in nutrition and a healthy lifestyle and the history and importance of agriculture in relation to the local economy. Volunteer presenters introduced students to healthy food choices, created an ongoing awareness of the importance of eating locally grown specialty crops, and addressed the role that students play as consumers in helping to maintain agriculture as a strong component of both the local and State economies.

Additionally, 20 fourth grade farmers' market programs were delivered at various schools throughout SJC. At each location, volunteers focused on four specialty crops, educating students on the commodities history, nutritional benefits and how each is grown. Students were then allowed to taste each commodity. Students who participated in the educational segment were given tickets to use for a free piece of produce at the on campus farmers' market that followed the lesson. The market consisted of a variety of specialty crops.

The program was motivated by the importance of teaching San Joaquin County students the nutritional and economic benefits of eating locally-grown specialty crops and the vital role agriculture plays in the local economy. In the past 10 years, San Joaquin County has transformed from a primarily rural locale to a more suburban locale for Bay Area commuters. As a result, more students and residents are unaware of the importance of agriculture. This program exposes students, most for the first time, about agriculture as the backbone of the local economy. Additionally, the third grade field trips tie in with third grade curriculum; which teaches about county history, of which agriculture is a large part. The fourth grade farmers' market program continues the education at a point in students' lives when they start making their own food choices. AgVenture and the Farmers Market program seek to stress the importance of specialty crops as healthy food choices in the students' lives to promote healthy living.

The program built on the 2011 Specialty Crop Block Grant Program Project 3. To build on the previously funded project, a fourth grade farmers' market program was added. During the project, 20 school farmers' market programs were delivered at various schools throughout SJC. At each event, students were taught about four different specialty crops. This built on the information the students received at their third grade AgVenture field trip and continued to teach students about agriculture and nutrition, aiding in information retention and application.

Project Approach

The following activities were completed in order to achieve the goals and objectives for the program:

- The Ag Commissioner and the AgVenture Coordinator secured AgVenture field day locations and obtained all necessary insurance (October 2012/13/14).
- The AgVenture Coordinator purchased all the supplies for the program (October 2012/13 and September – October 2014).
- The AgVenture Coordinator mailed invitations to all San Joaquin County schools, specialty crop farmers, producers, and volunteers, and then coordinated registration (October 2012/13/14).
- The Ag Commissioner and the AgVenture Coordinator recruited 450 specialty crop farmers, producers and volunteers for each field day (October - March 2012/13/14 and October 2014).
- The AgVenture Coordinator distributed informational materials to students, parents, teachers and volunteers (October - March 2012/13/14 and October 2014).
- University of California Cooperative Extension (UCCE) representative developed pre/post field day tests (October - March 2012/13/14 and October 2014).
- The AgVenture Coordinator developed bus schedules for transportation of students (October - March 2012/13/14 and October 2014).
- The AgVenture Coordinator arranged for portable bathrooms to be located at the South County field day in Manteca (October 2012/13/14).
- The AgVenture Coordinator conducted one-hour workshops with San Joaquin County teachers about information presented at the field days and how to integrate it into lesson plans (October 2012/13).
- The Ag Commissioner and the AgVenture Coordinator conducted three field days per year for San Joaquin County third graders and an additional southern county event in November of 2014 (South SJC - November 2012/13/14, central SJC - January 2013/14, and north SJC - March 2013/14).
- U.C. Cooperative Extension representative in collaboration with San Joaquin County teachers conducted pre/post-field day tests (southern SJC – November 2012/13/14, central SJC - January 2013/14, and northern SJC- March 2013/14).
- The AgVenture Coordinator prepared and disseminated a program final report.
- The Farmers Market Coordinator conducted Farmers Markets to fourth grade students at 20 low-income schools from 2013-2014. Eight schools were conducted in August-October of 2013, three schools were completed in May of 2014 and the remaining nine schools were finished August-September of 2014.
- University of California Cooperative Extension (UCCE) conducted pre and post surveys

to the twenty low-income schools over the two years.

- UCCE prepared all produce for the twenty schools' taste test portion of the Farmers Market Program.
- The Stockton Certified Farmers Market manager obtained locally grown produce and coordinated the entire outdoor farmers' market for each school site.
- The Farmers Market Coordinator conducted meetings with the agriculture education committee to review the program and make suggestions for improvement. A final meeting was held to discuss the program as a whole (October 2013, June 2014 & September 2014).
- The Farmers Market Coordinator prepared reports at the conclusion of each calendar year (December 2013 and December 2014).

Over the course of the entire project, seven third grade field trips were planned, coordinated and managed. Each year, a trip was held in southern SJC in the fall, central SJC in January and in northern SJC in March. This required the coordinator and supporting entities to secure facilities, acquire over 1,800 volunteers with experience in specialty crops, and coordinate with all county school districts. This required emails and letters to the school districts to register classes and develop transportation schedule for each event that suited everyone's needs. Additionally, a pre/post test was developed in collaboration with UCCE staff that was distributed for each field trip.

The fourth grade farmers' market program solely benefitted specialty crops as no other commodities were introduced to students. At the third grade AgVenture events, students were exposed to some non-specialty crop commodities. These commodities made up a small portion of the program and SCBGP grant funds were not used to directly promote them.

AgVenture was able to accomplish all goals and outcomes during the project period. The project partners have contributed to the success of the program. The partners provided the following services:

- County of San Joaquin: Provided program oversight, volunteer support, and provided nearly $90,000 in-kind support.
- San Joaquin Farm Bureau Federation: Provided lunch for volunteers at all field days and volunteer support.
- UCCE: Provided data analysis of pre-and post-tests, curriculum assistance and volunteer support for both programs.
- Natural Resources Conservation Service: Provided volunteer support.
- California Women for Agriculture: Provided breakfast for volunteers at the third grade field trips and volunteer support for both programs.
- San Joaquin County Office of Education: Provided grant and proposal development assistance, and volunteer support.

Goals and Outcomes Achieved

To measure the impact of the duties and tasks described in the work plan, certain monitoring actives were utilized. These activities included the following:

- The AgVenture coordinator and UCCE staff developed a pre/post test to determine student knowledge of SJC specialty crops and nutrition in relation to healthy living and the importance of agriculture's role in history and the local economy (October 2012/13/14).
- UCCE representative in collaboration with San Joaquin County teachers conducted pre and post field day tests (Southern SJC - November 2012/13/14, central SJC - January 2013/14, and north SJC - March 2013/14).
- UCCE representative conducted pre/post tests about student and parent knowledge of SJC specialty crops with parents before and after each fourth grade farmers' market program (October 2012 - September 2014).
- The AgVenture coordinator kept a database of the volunteers for each of the field days, the number of field days and farmers' market events.

Goal 1: Provide all SJC third graders the opportunity to learn about SJC specialty crops, nutrition in relation to healthy living, and the importance of agriculture's role in history and economics through two series of three free field days and an additional south county only free field day provided in November 2014, to be maintained at this level for the 2012-14 school years and measured by the number of offered field days.

This goal has been met. The program served 26,000 third grade students from throughout the county. AgVenture provided seven field days held on the following dates and locations:

- November 7, 2012, November 7, 2013, November 6, 2014 (South County- Manteca)
- January 16, 2013, January 15, 2014 (Central County-Stockton)
- March 6, 2013, March 4, 2014 (North County-Lodi)

Goal 2: Provide SJC fourth graders the opportunity to increase and reinforce the knowledge learned during the field day from the previous year through ten free farmers' markets to be maintained at this level for the 2012-14 school years and measured by the number of offered farmers' markets.

This goal has been met. The program served 1,430 fourth grade students from throughout the SJC. AgVenture provided 20 famers' markets held in the following months and schools:

- August 2013– Washington
- September 2013 – Golden West, South West, Roosevelt, Taylor, Marshall
- October 2012 – Cleveland, August Knodt
- May 2014 – Collegeville, Tokay Colony, Farmington
- August 2014 – Live Oak, Joseph Widmer, Pittman Charter
- September 2014 – Ripon, Linden, Lockeford, Alex Spanos, Aspire Port City, Banta

Goal 3: Participating students will increase their knowledge of SJC specialty crops and nutrition in relation to healthy living from the current 10% to 15%, as measured by pre/post field day tests.

This goal has been met. Students were provided with pre-and post-test measuring their knowledge of nutrition in relation to healthy living, indicating an increase of 22%. Program partner, UCCE conducted the analysis of the pre-and post-tests.

Goal 4: Participating students will increase their knowledge of the importance of agriculture's role in history and the local economy from the current 10% to 15%, as measured by pre/post field day tests.

This goal has been met. Students were provided with pre-and post-test measuring their knowledge of the importance of agriculture's role in history and the local economy, indicating an increase of 18%.

Goal 5: Participating parents at the farmers' markets will increase their knowledge of SJC specialty crops (no such baseline currently exists) by an increase of 15% as measured by pre/post farmers' markets tests.

This goal has been met. Parents were provided pre-and post-tests measuring their knowledge of agricultures' role in SJC and their knowledge of specialty crops. The tests show the parents knowledge of agriculture's role in SJC increased by 16% and their knowledge of SJC specialty crops also increased by 16%.

Goal 6**:** AgVenture will create an ongoing partnership between the agriculture industry, SJC, and SJC school districts by increasing the level of support from the current level of 1,100 volunteers to 1,200 volunteers from the agriculture industry to contribute presentations for students, and to help with program operations, as measured by the partner database.

This goal has been met. AgVenture recruited 450 volunteers per field day for a total of 1,350. An additional 500 were recruited for the event in November 2014. The AgVenture Coordinator in collaboration with the Agricultural Commissioner's office cross referenced farmers with the eligible specialty crops to determine eligible specialty crop farmers.

Goal 7**:** Reinvest SFMP earned income into the AgVenture Program

This goal was met. Once fourth grade students spent their tickets (earned by answering questions during presentations) purchasing produce at the School Farmers' Market the market was opened up to the elementary school's entire student population. During this segment of the market specialty crop produce was sold at $0.10/piece. Students (including the fourth graders) and their parents spent $4,753.87 on specialty crops at the markets. This income was reinvested directly into the SFMP by purchasing additional specialty crop produce for the markets. This allowed a greater number of students and parents to participate in the program.

Below are some of the most successful outcomes from the project, reported statistically:

- Between 12% and 18% of the students' responses indicated they gained a new understanding of agriculture's role in San Joaquin County.
- On average, 21% of the students' responses indicated they gained a new understanding of agriculture's role in San Joaquin County and specialty crops by going through the farmers' market program.
- Respondents indicated an 18% increase in understanding that good nutrition included eating specialty crops such as fruits and vegetables.

- Written responses to the open-ended question "Agriculture is important because…?" indicated students developed more of an understanding of the importance of San Joaquin County agriculture after participating in AgVenture. In their responses students mentioned specialty crops 43 more times from pre- to post-survey.
- Similar to their children, the parents of fourth graders seemed to increase their knowledge of agriculture's role in San Joaquin County by 13% to 33%.
- Over 27,430 students and nearly 1,900 teachers and chaperones were educated about specialty crops and nutrition as a result of the grant.

Beneficiaries

Over 26,000 SJC county third graders in public school had the opportunity to attend an AgVenture field trip. The students, teachers and chaperones directly benefited from the experiential learning provided at the field trips. A secondary group of beneficiaries were their family and friends who they shared information with as a result of the program. Volunteers and partners benefited by being able to share information with students and teachers who not only represent current purchasers of specialty crops, but future purchasers as well.

In total, over 26,000 third graders and an additional 1,900 chaperones and teachers attended the third grade field trips. Attendees were educated by 1,850 volunteers from across the county who collectively donated over 6,000 hours of volunteer support to the program.

Over 1,430 fourth grade students and nearly 75 parents took part in the farmer's market program. Over 30 specialty crop farmers also benefited from the program as the goods were purchased from local farmers for the program.

The program also benefited 1,900 volunteers who had the opportunity to explain the importance of specialty crops to future consumers through both programs.

The quantitative data illustrating how the program affected the beneficiaries is explained in the goals and outcomes section of this final report.

Lessons Learned

During the course of the project, both program coordinators learned many lessons. For the third grade program, a few transportation issues arose; whether it was a bus breaking down or simply not staying on time. Moving forward the schedule will be adjusted to try and offset these issues. Depending on the time of year the event took place and the lack of rain, many volunteers cancelled at the last minute, putting strain on the coordinator and schedule. Moving forward, additional "back up" volunteers will be contacted in case such issues arise. Having pre-packaged specialty crop presentations ready for volunteers was an idea developed throughout the course of the project that helped when a last minute cancellation resulted in an ill prepared fill in. Furthermore, emails are being used whenever possible to reduce cost.

For the fourth grade program, parental participation was an issue, as parents work during school hours. Additionally, the availability of fresh specialty crops for the students to taste and purchase dictated the timing of the program. However, the coordinator was able to adjust the schedule to present at smaller schools when less specialty crops was available and larger when there was more available.

The biggest unexpected outcome of the program was the benefit to secondary audiences such as parents and chaperones. Their increase in knowledge from attending the farmers' market programs was astounding. Some increased their knowledge of the importance of agriculture in SJC by 33%.

Additional Information

Tokay Colony School Farmers' Market Event – fourth graders are purchasing specialty crops with earned tickets.

Stockton (November 2013) third grade AgVenture field trip tomato talk by Heinz volunteers.

USDA Project No.: 5	**Project Title:** Consumer Outreach to Enhance Awareness and Marketing of Specialty Crops in the Sierra Foothills	
Grant Recipient: The Regents of the University of California, Davis	**Grant Agreement No.:** SCB12005	**Date Submitted:** December 2015
Recipient Contact: Roger Ingram	**Telephone:** (530) 889-7385	**Email:** rsingram@ucanr.edu

Project Summary

Although Placer and Nevada Counties have a vibrant local food movement, less than two percent of the population buys local specialty crops regularly. A wide range of specialty crops is grown locally and increasing sales will also lead to a more economically viable specialty crops sector in local agriculture. Increasing consumption of fresh fruits and vegetables is critical to combating the growing health crisis of obesity, diabetes, and other diseases. This project will support local specialty crop farms and improve healthy eating among residents.

This project was important because less than two percent of the population buys local specialty crops regularly, despite an active local food movement. Increasing consumption of fresh fruits and vegetables is critical to combating the growing health crisis of diseases related to unhealthy diets. A wide range of specialty crops are grown locally, and increasing sales would lead to more economically viable specialty crop operations in the Northern California foothill area. This project improved healthy eating habits among residents and supported local farms. The project is timely because it builds on the fact that there are more direct agricultural sales for consumption in Placer and Nevada than in the rest of California or the United States. Outreach and promotion efforts to encourage eating more locally grown specialty crops had more impact because there is already a strong cadre of farmers directly marketing to consumers.

This project did not build on a previous Specialty Crop Block Grant Program project.

Project Approach

Specialty crop tastings at Ag Events: The project team held eight specialty crop tastings and outreach events at various fairs and agricultural festivals, including three at the Mountain Mandarin Festival (2012, 2013, and 2014). In addition, the project team conducted consumer surveys about which local specialty crops were in season and definitions of “local” (details under consumer surveys). The project team also distributed 2,916 samples of various seasonal local specialty crop fruits including persimmons, apples, and plums.

Consumer Surveys: E-mail Surveys of Eat Local event participants: The project team conducted two e-mail surveys of consumers who had participated in an Eat Local event and signed up to receive information about the Eat Local project. The surveys were conducted in spring and fall 2014 to assess trends in local specialty crops purchasing: 156 consumers responded. Results showed:

- 36.15% bought more local produce after participating in an Eat Local event
- 60.75% purchased new or different local fruits and vegetables after participating in an Eat Local event 61.65% bought fruits or vegetables featured in the recipe after tasting the recipe at an event

- 83.25% said that the specialty crops recipe cards made it easier to cook and eat locally grown fruits and vegetables.

Dot surveys: The project team conducted a total of 36 dot surveys at various fairs and festivals, certified farmers' markets, and public venues such as libraries. The following three different surveys were conducted:

1. Consumer definitions of local fruits and vegetables: 24 surveys, 1877 respondents
   - 42% of consumer respondents define local as "from my county"
   - 42% define local as "from my county and adjacent counties"
   - 41% purchase most of their fruits and vegetables at farmers' markets
   - 49.9% purchase most of their fruits and vegetables at grocery stores
2. Attendance and buying habits at certified farmers' markets: 7 surveys, 701 respondents
   - 59% of respondents shop weekly at farmers markets
   - 38.6% have shopped at farmers markets for 6 or more years
   - 22% shopped for less than one year
   - 13% purchase 75% to 100% of their fruits and vegetables at the farmers market
   - 37% buy less than 25% of their produce at farmers' markets
   - 35.5% said greater availability of local produce at grocery stores would make purchasing more convenient.
3. At farmers' market tasting events, we surveyed consumers about produce purchases after tasting a specialty crop recipe: 5 surveys; 335 respondents
   - 29% of consumer respondents purchased the fruit or vegetable featured in the tasting
   - 24.6% of purchased more of the produce featured in the tasting than the previous week
   - 37.6% spent $10 - $25 on fruits and vegetables on the day of the tasting

Point of sale materials: The project team developed point of sale and consumer outreach information focusing on nutrition, preparation, and availability of local specialty crops. The project team developed 40 seasonal specialty crop recipes cards which were printed with nutrition information, including four translated into Spanish. The project team distributed a total of approximately 40,900 recipe cards to consumers. See Appendix I for list of recipe cards and the percentage of Specialty Crop ingredients.

The project team also developed wallet cards (distributed 1,050) and refrigerator magnets (distributed 1,100) that show what's in season in Placer and Nevada Counties at various times of year. 24 information sheets were developed on specific crops for consumer education at events.

Website and Social Media Outreach:
Eat Local website: The website was developed and went online in January 2013 (the website link is available at the end of the report). It disseminates information about buying and eating locally; with links to help consumers find nearby farms and stores that sell local produce and tips for buying and storing local produce. All the recipes developed by this project are available for download on the site. 29 Eat Local blogs were posted over the course of the project, which had a total of 1,170 hits. Topics included seasonal produce shopping and storage tips, eating local during the drought, farmer profiles, consumer and farmers' market price survey results; and program highlights. The website had a total of 7,526 page views from November 2013 to June 2015, and page views increased by 157% from September 30, 2014 to June 30, 2015.

The Eat Local Placer and Nevada Facebook page had 601 "likes" on June 30, 2015, a 600% increase from January 2013. It had a total reach of 56,928 people over the course of the project.

Foothill Farming Website: The Foothill Farming website can be viewed at: http://ucanr.edu/sites/placernevadasmallfarms/ , which is targeted to local specialty crop farmers, and was used to keep farmers updated on the project and provide non-formal marketing education. The website had a total of 52,054 page views from November 2013 to June 2015. 17 blogs about specialty crops and marketing were posted and had 13,533 hits. The Foothill Farming Facebook page has 212 likes, a 160% increase over January 2013.

Community dinners: The project team conducted four community dinners to reach out to consumers and show them the variety and quality of local produce. Each dinner was prepared by local chefs with seasonal specialty crop products. The project team held two dinners in Placer and Nevada Counties. 472 people participated, including 80 farmers.

Beginning Farming Academy: A total of six Beginning Farming Academies were held and 74 prospective farmers were trained. Training included marketing strategies and information such as using Specialty Crop recipes and nutritional information to increase sales. Additionally, booth set-up and displays, customer interaction, and tracking sales were activities that were also a part of the training process.

Marketing workshops: 1,264 specialty crop producers are using nutritional information as a marketing tool. Registration lists and evaluations were used to monitor that only specialty crop producers were attendees.

The trainings included:

- Marketing Academy 2013
- Nevada County Food and Farm Conferences, 2014 & 2015
- Sierra College Direct Farm Marketing – 2013, 2014, 2015
- Nevada County Certified Growers' Market Annual Meeting, 2014 and 2015
- Farm Business Planning for grant year 2013, 2014, 2015
- 50 farmers' markets tastings were conducted throughout the grant period which involved outreach to specialty crop farmers and distribution of recipe cards to help increase sales.
- Beginning Farmer Academy took place in grant years 2013, 2014, 2015

Farmers' Market Tastings, Cooking Demonstrations, and Information Tabling:

- The project team conducted 50 farmers' market specialty crop tastings and distributed 12,406 samples at 11 different Certified Farmers' Markets. Specialty Crop tastings were held in Auburn, Roseville, Rocklin, Lincoln, Tahoe City, Truckee, Nevada City, and Grass Valley.
- Specialty Crop tastings were done in collaboration with Foothill Farmers' Market Association, Nevada County Growers' Market Association, Grass Valley Downtown Association, Brunswick Farmers' Market, Sierra Fresh, and Nevada City Farmers' Market.
- Conducted 16 cooking classes showcasing specialty crops and demonstrations for 458 consumers in conjunction with farmers' market specialty crop tastings, agricultural events, and stand-alone classes.

- Provided an information table at 58 farmers' market specialty crop tastings and agricultural events. Information table included: featured specialty crop information sheets, recipe cards, farmers' market schedule, what's in season tri-fold, and Eat Local website information.

Outreach and promotion to increase low-income and senior participation in purchasing specialty crops at local farmers' markets.

- Conducted 60 specialty crop tasting and distribution events that reached 8,994 low-income adults and children. These included: tastings at three low-income schools in Auburn and Grass Valley, Family Garden Day for Early Head Start in Auburn, two farm tours, Auburn Interfaith Food Closet and Salvation Army in Auburn, Nevada County Food Bank, and Friendship Club for at-risk teen girls in Grass Valley.
- Conducted 16 specialty crop cooking classes including nutrition information in collaboration with: Chapa De Indian Health Program diabetes class, Rock Creek Preschool, Mothers in Recovery, Sun City Lincoln Hills, Placer County WIC (Women, Infants, and Children), and Friendship Club for at-risk teen girls.
- Developed two cooking videos on preparing Massaged Kale Salad and Cabbage Citrus Slaw. These videos are posted on-line at our Eat Local Placer Nevada webpage and have been promoted on the Facebook page. There have been 132 views of the cooking videos.
- Conducted 9 specialty crop tastings for 518 seniors. These included: tastings at Auburn Senior Center, Salvation Army in Auburn, Sun City Lincoln Hills in Lincoln, and Gold Country Community Services in Grass Valley.

Develop and implement farmers' market specialty crops voucher program.

- Distributed a total of 6,789 vouchers that were worth $5 each for redemption of specialty crops only at Certified Farmers' Markets in Placer and Nevada Counties. A total of 4,465 vouchers were used to purchase specialty crops for a total value and return to specialty crop farmers of $22,435. The redemption rate was 65.7%, which is very high for a voucher program. Vouchers redeemed by low income and senior audiences totaled $2,535.

Specialty crop tastings increased overall customer traffic in Certified Farmers' Markets because of the added publicity and attraction of the tastings and produce vouchers. Specialty crop vendors reported sales increases. However, tastings solely promoted specialty crops and funds were expended only to enhance the competitiveness of specialty crops. Only specialty crops were listed in press releases and on signage. Recipes averaged 92% specialty crops (see Appendix I for details).

All produce purchases made with SCBG funds were approved by Project Co-Directors. All produce vouchers distributed included the following statement: "Redeemable for fruits, vegetables & fresh herbs only." Farmers' market vendors received orientation as to what the vouchers could purchase (specialty crops only). Produce vouchers were paid for by University California Cooperative Extension (UCCE) when they were redeemed by each Farmers' Market Association. UCCE then included that amount when invoicing for quarterly project expenses.

Project Partners were critical to the overwhelming success of this project.

The project team collaborated with five Farmers' Market Associations to deliver specialty crops tastings and conduct consumer surveys. These include:

- Foothill Farmers Market Association: collaborated on specialty crop tastings, samplings, and consumer surveys, cooking demonstrations, producer surveys and producer education events in farmers markets.
- Nevada County Certified Growers Market: collaborated on specialty crop tastings, samplings, consumer surveys, producer surveys, and producer education events in farmers markets.
- Grass Valley Downtown Association: Collaborated on farmers markets specialty crop tastings and consumer surveys
- Nevada City Farmers Market: collaborated on specialty crop tastings and samplings
- Brunswick Farmers Market: collaborated on specialty crop tastings and samplings
- Sierra Fresh Farmers markets: collaborated on specialty crop tastings, samplings, cooking demonstrations, and consumer surveys in farmers markets.

Other collaborators:

- University California CalFresh: collaborated on outreach to schools, with a particular emphasis on schools with a high percentage of students who are eligible for the free and reduced lunch program. Provided locally grown specialty crops for sampling and tasting.
- Auburn Interfaith Food Closet, Salvation Army, Auburn, Placer Food Bank Collaborative and Nevada County Food Bank: collaborated to provide recipes, samplings, tastings, produce and/or produce vouchers to food bank clientele.
- PlacerGROWN: Collaborated on October harvest festival in Rocklin, cooking demonstration during the California State Fair and organization of Placer County community dinner.
- Nevada County GROWN: Collaborated on AgSperience at the Nevada County Fair, Bounty of the County at the Draft Horse Classic, and organization of Nevada County community dinner.
- Auburn Elementary School, Bell Hill Academy, Scotten School: collaborated to present specialty crop tastings at family events in low-income schools.
- Early Head Start, Auburn: collaborated on Family Garden Day and two farm tours.
- Friendship Club, Chapa De Indian Health Program, Rock Creek Preschool, Mothers in Recovery, Placer County WIC (Women, Infants, and Children), Sun City Lincoln Hills: Collaborated to provide cooking and nutrition classes for their clientele, helping the project to reach more low-income and senior audiences.

Goals and Outcomes Achieved

The overall goal was increasing community awareness and purchasing of seasonal local specialty crops. This goal was achieved. Measurement metrics were met or exceeded for each outcome.

1. Dot Surveys: Target: 20% of surveyed patrons purchase featured produce. Dot survey results show that 33% of surveyed patrons purchased the featured produce after the tasting. E-mail surveys showed that 61% of respondents who tasted a specialty crops recipe purchased the featured produce.
2. Farmers' market vendor surveys to assess whether tastings increased sales: Target: 20% sales increase at each event. The average increase in sales for each tasting event was 35%, exceeding the target.

3. Email Survey: Target: 30% increase in specialty crops purchases. The aggregated results of the two e-mail surveys showed that 35% purchased more produce after participating in an Eat Local event, and 61% purchased new or different produce, exceeding the target.
4. Eat Local website hits and visits increase by 30% per year. Target: 75% increase over life of the project. The website went online in January 2013. However, the project team was unable to access statistical data until November 2013. The measurable outcomes were initially planned to be measured as hits; however the metric for website traffic changed from hits to page views, so page views are reported. From November 2013 to September 30, 2014, page views totaled 2,923. From October 1, 2014 to June 30, 2015, page views increased from 2,923 to 4,603, a 157% increase.
5. County Fair Surveys: Annual surveys at County Fairs to determine whether more people are able to identify local seasonal specialty crops and where to purchase crops. Target is 20% increase over 2013 baseline, benchmark 15%. Overall, an average 89.1% of consumers surveyed were able to identify fruits and vegetables that were in season at the time of the survey. Averaged together, the overall increase from 2013 was 15%.

Long-term outcomes of increasing consumption of specialty crops are the improvement in healthy eating that leads to a healthier population and leads to specialty crop farms becoming more economically viable. The project team now knows that providing specialty crop tastings, recipes, and produce vouchers is a great motivator for consumers to eat more fruits and vegetables. Providing the kind of incentives as this program did to increase consumption of specialty crops is critical to continue to motivate consumers.

Farmers now know that providing samples and recipes to consumers increases specialty crops sales. If the farmers continue to use those strategies, the long-term outcome is increased specialty crop sales and improved economic viability.

Actual Accomplishments versus Goals:

1. <u>Increase consumer awareness and interest in purchasing local specialty crops</u>
   Consumer survey results showed that the combination of tasting local specialty crop produce, a recipe card with nutrition information, and a voucher incentive increased sales for local specialty crop producers. Survey results showed that 36.2% of the consumers UCCE reported purchasing more local produce after participating in an Eat Local event. 60.8% of the consumers reported purchasing a new locally grown fruit or vegetable, 61.7% bought fruits or vegetables featured in the recipe after tasting at an event, and 83.3% reported that the recipe cards made it easier to use locally grown produce.

2. <u>Educate consumers about seasonal availability, nutritional value, preparation and purchase points for local specialty crops</u>
   This project provided nutritional information and where to buy local specialty crops to over 201,000 adults, youth, low-income, and senior audiences. UCCE handed out 43,050 point-of-sale materials. These include recipe cards that included preparation instructions, nutritional information, “What’s in Season” wallet cards, and refrigerator magnets that help consumers identify local produce that is in season. Combining the projects Facebook and webpage traffic, as well as local media coverage, the numbers indicate UCCE reached over 175,000 Placer and Nevada County residents.

3. Educate producers about the nutritional value of specialty crops and how to communicate these benefits to consumers
   UCCE has provided information on using nutritional value of locally grown specialty crops to 1,264 producers. Nutrition information and training were delivered directly at 50 farmers' markets where specialty crop tastings have been conducted, 3 Farm Business Planning short courses, 6 Beginning Farming Academies, at monthly Farmer-to-Farmer Breakfasts, Nevada County Food and Farm Conference, Nevada County Growers' Market Annual meetings, and at the Direct Farm Marketing course at Sierra College. Registration lists were maintained to ensure specialty crop producers were attendees at the trainings and academies conducted.

4. Improve consumer connections to local specialty crop farms and farmers' markets by reducing barriers to access
   UCCE has organized farm tours for the general public as well as for low-income and youth audiences. These tours have been both stand-alone events and been combined with community dinner events. The program provided $5 produce vouchers to a variety of consumers (including low income and senior consumers) that can be used to purchase specialty crops only at farmers' markets (the farmers were trained to only provide specialty crops to redeem against the vouchers). Finally, the project team has provided tasting events and specialty crop distributions at local food closets, food banks, and Salvation Army. These connections reached 9,512 low-income and senior audiences.

UCCE met or exceeded all of the intended goals and targets. See above on comparison of goals with actual accomplishments.

The project achieved the overall goal of improving eating healthy specialty crops among residents and supporting local farms. This goal was achieved through work plan implementation that far exceeded grant plans. This included:

- Reached over 201,000 area consumers through the Eat Local website, blog, Facebook, and Pinterest pages.
- Conducted a total of 157 tastings, specialty crop cooking classes, and community dinners that reached 25,887 adults, youth, low-income, and senior audiences directly.
- UCCE distributed 6,789 farmers' market produce vouchers and handed out 40,900 recipe cards and 1,050 "What's In Season" Wallet cards and 1,100 What's In Season Refrigerator magnets.
- Consumer survey results showed that providing a combination of a specialty crop tasting, recipe card with nutrition information, and a voucher increases sales for local specialty crop producers. The project directly increased local specialty crop farmer sales by $49,232 through produce purchases and farmers' market vouchers.
- Collaborated with Foothill Farmers' Market Association, Nevada County Growers' Market, Grass Valley Downtown Association, Brunswick Farmers Market, Sierra Fresh, and Nevada City Farmers' Market to conduct farmers' market specialty crop tastings.
- UCCE conducted 50 farmers' market specialty crop tastings in Placer County (2 different markets in Auburn, Rocklin, Roseville, Lincoln, and Tahoe City) and Nevada County (3 different markets in Grass Valley, 2 different markets in Nevada City, and Truckee).

- Collaborated with Nevada County Food Bank, Auburn Interfaith Food Closet, and Salvation Army to distribute $9,616 of locally grown specialty crops to low-income and senior community residents. A total of $2,535 in specialty crop certified farmers' market vouchers were redeemed by low-income and senior community residents.
- Collaborated with nutrition programs in Placer and Nevada Counties to provide $1,000 in locally grown specialty crops for tastings conducted at low-income schools and conduct tasting at seven low-income school nutrition events.
- Trained 51 volunteers who provided 286 hours of service to assist with tastings.

Beneficiaries

Twelve-hundred local specialty crop farmers will benefit from this project by increasing their knowledge of the nutritional value and health benefits of specialty crops, and using that information to market the crops more effectively. In addition, 25,887 consumers benefitted through specialty crop tastings, samplings, community dinners, cooking classes, farm tours and other events. Another 175,113 area residents benefitted through increased awareness of local specialty crops and their nutritional benefits. These consumers were reached through our Eat Local website, blogs, Facebook, Pinterest, and other media outreach.

Specific specialty crop commodities benefitted through this project were:

- 71 Specialty Crop farmers benefitted directly through the project's purchases of produce and increased sales.
- 80 farmers benefitted directly through attendance at community dinners and contacts with consumers.
- 74 beginning farmers benefitted from training.
- Over 1,200 farmers benefitted directly through receiving training and/or information from the project.
- There are approximately 697 Specialty Crop farms in Placer/Nevada, all of whom benefitted either directly or indirectly through this project from increased local specialty crop sales.
- The project directly increased sales of local specialty crops by $49,232.

Lessons Learned

- Publicity and media outreach is essential to draw consumers to events. Each tasting was promoted with a press release, website schedule, and Facebook posting. Tastings had a set schedule and were conducted over a two-hour period. An attractive display at tastings help draw customers to the booth. This included a banner, table covering with the Eat Local logo, multi-row plastic holders for recipe and nutrition information cards, and a designated area for handing out samples and one for information.
- People handing out samples or information need to always be standing, say hello to each person passing by, and politely ask if they would like to try a sample. Consumers were required to try a sample before they received a specialty crop voucher.
- A great deal of equipment is necessary to meet Environmental Health Department regulations for providing tastings. Clear procedures and appropriate serving containers and utensils are critical to make tasting events run smoothly. Systems for recording sample numbers, contacts, and other critical data also must be developed.
- Dot surveys proved to be popular with consumers and most participated readily.

- Vouchers were a very effective incentive to consumers to purchase specialty crops.
- Specialty Crop recipes should be easy and quick to prepare - 20 minutes or less. They should have no more than 10 ingredients and not require specialized utensils or equipment. Recipes must yield good tasting dishes consistently. A recipe should be tested on consumers before it is provided at a tasting events or becomes a development of a recipe card.
- The project team developed a good network and system for sourcing local specialty crops. The project hired people who knew many of the farmers in Placer and Nevada Counties. It is important to create a list of interested farms, what they grow, when it is available and start procurement at least one week before the event. The easiest system was to pre-order the produce and pick it up at a farmers' market.
- Conducting a number of tastings in a row is a great way to work out systems. However, it can be exhausting for staff and volunteers. Finding someone (in this case, a market manager) who is versed in tasting procedures is extremely helpful to learn the process and regulations.
- If a commercial kitchen is available, pre-preparation of samples for tastings reduces the number of staff and time to set up a tasting.
- Community Dinners were positive from the standpoint of having farmers and consumers at the same table networking and sharing a meal together. The negative part was the amount of labor it took to conduct the event with little in the way of tangible results. The dinners did not increase traffic at local markets. The consumer attendees were largely already purchasing local specialty crops. Therefore, the other events for this project were better options to reach the results of this project.
- Vouchers did not work well with low-income audiences due to transportation barriers. The project team found it more effective to purchase the specialty crops and distribute it directly in collaboration with a food bank, food closet, or Salvation Army.

The project team can accurately evaluate the increase in Specialty Crops sales from project purchases and produce vouchers. However, overall county sales increases are difficult to evaluate accurately, as overall sales data from markets is difficult to gather. This is primarily due to the hectic nature of selling in a farmers' market. It also illustrates the need for farmer training in quick, simple recordkeeping so they can accurately account for sales.

Farmers' markets struggle to have adequate customer traffic and sales, and the project team discovered that a marketing and promoting the event can lead to increased customer traffic sales increases of as much as 28% for the week of the event and some increase carries over to the following week. Providing vouchers encourages consumers to purchase more than the value of the voucher. For events for which that provided clear data, the increased purchase value is more than double the value of the voucher.

Conducting tastings is a very labor-intensive activity, and skilled staff is needed as well as volunteers. For most tastings, four or more people were needed to prepare and distribute samples and information.

Additional Information

Eat Local Placer Nevada website: www.ucanr.edu/sites/EatLocalPlacerNevada/
Eat Local Placer Nevada Facebook page: www.facebook.com/EatLocalPlacerAndNevada?fref=ts
Eat Local Pinterest Page: www.pinterest.com/EatLocalPN/
Recipe Cards: www.ucanr.edu/sites/EatLocalPlacerNevada/Recipes/

Foothill Farming: www.ucanr.edu/sites/placernevadasmallfarms/
Foothill Farming Facebook page: www.facebook.com/FoothillFarming?fref=ts

	Seasonal Recipe Card	% Specialty Crops
1	Arugula, Fennel, and Beet Salad	95%
2	Asian Cucumber Salad	96%
3	Asparagus and Radish Salad	77%
4	Basil Pesto	94%
5	Beet Chips	99%
6	Cabbage Citrus Slaw	100%
7	Chard Spring Rolls with Almond Butter Sauce	97%
8	Curried Butternut Squash with Mandarin	77%
9	Eggplant Stir Fry	92%
10	Fennel, Arugula & Beet Salad	95%
11	Grilled Summer Vegetables	99%
12	Mandarin, Radish, and Apple Salad with Winter Greens	99%
13	Massaged Kale Salad	96%
14	Melon & Cucumber Salad	87%
15	Mixed Greens with Mandarins and Pistachios	98%
16	Oven-Roasted Root Vegetables	99%
17	Peach & Berry Smoothie	80%
18	Peach Salsa	100%
19	Pear and Carrot Salad with Walnuts	98%
20	Pear and Walnut Crisp	72%
21	Persimmon Latkes	67%
22	Persimmon Relish	99%
23	Potato Soup with Collard Greens	96%
24	Quick Boiled Cabbage	98%
25	Roasted Beet Salad	99%
26	Sautéed Pears with Chard	99%
27	Simple Sautéed Kale	99%
28	Spring Salad with Fresh Fruit and Nuts	99%
29	Spring Vegetable Tabouli	69%
30	Stewed Sweet Pepper Sauce	99%
31	Strawberry Orange Smoothie	80%

32	Summer Squash Sauté	99%
33	Sweet Potato Mash	95%
34	Tomato Bruschetta	75%
35	Winter Greens with Mandarin, Radish, & Apple	98%
36	Winter Squash Soup with Almond Butter	98%
	Average percent Specialty Crops	92%

n.b. % Specialty Crops = vegetables, fruit, fresh herbs, tree nuts, olive oil, vinegar made from specialty crops.

The recipe cards and other information are available on the Eat Local Placer Nevada website at *www.ucanr.edu/sites/EatLocalPlacerNevada*

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 06	**Project Title:** Promoting California Grown Specialty Crops in Santa Clara County	
Grant Recipient: Community Alliance with Family Farmers	**Grant Agreement No.:** SCB12006	**Date Submitted:** December 2015
Recipient Contact: Diana Abellera	**Telephone:** (510) 832-4625 x14	**Email:** abellera@caff.org

Project Summary

A 2010 Santa Clara County Public Health Department (SCCPHD) report discovered that 55% of residents and 27% of youth in Santa Clara County are obese or overweight. To counter this growing epidemic, the region is developing a burgeoning movement to improve access to healthy food like specialty crops in underserved areas, but few are utilizing and marketing California grown fruits and vegetables to promote consumption. Meanwhile, local agriculture reigns on the southern side of the county, valued at over $263 million by the latest Santa Clara Crop Report. Consumers are removed from the vulnerability of growing development pressures and diminishing profits that farmers in the region face because the products are predominantly exported outside of the region and state. SCB12006 spent the last two and a half years uniting local businesses together through a countywide 'Buy Fresh Buy Local - Santa Clara' (BFBL) marketing campaign that promotes California specialty crops and grows linkages between producers and consumers. Community Alliance with Family Farmers (CAFF) identified the following objectives to achieve the goal: 1) Conduct outreach to Santa County retail outlets, restaurants, worksites, and institutions to solicit participation in BFBL campaign; 2) Create a BFBL guide to market specialty crops in Santa Clara County; 3) Provide technical assistance to businesses interested in sourcing California specialty crops; 4) Launch a public education campaign to inform consumers about specialty crops and the benefits. Together these strategies catalyzed an informed population of consumers educated about and engaged with the food system.

Connecting the healthy food access and agriculture preservation efforts across the urban and rural areas of the Santa Clara Valley is needed now to ensure the economic viability of specialty crop growers in the face of an expanding Silicon Valley. As the technology industry continues to grow, more and more specialty crop producers are facing development pressures in Santa Clara County. This region was once known as the Valley of the Heart's Delight due to its vast orchards, but the community coming in is less aware of the history and of the remaining, strong agricultural presence in the south side of the county. As local food proponents are moving to the region, it is important to connect the urban populations on the north side of the county to the rich bounty on the south side to preserve the remaining agricultural lands and economy.

This project complements the 2011 Specialty Crop Block Grant Program Project 5: *Specialty Crop Market Enhancement and Promotion, Buy Fresh Buy Local North Valley* awarded to the Northern California Regional Land Trust (NCRLT). To reach the North Valley region, CAFF partnered with NCRLT in 2010 and 2011 to produce the original BFBL food guide, a tool used to gather information about California specialty crop producers, retailers, and restaurants. NCRLT conducted on the ground outreach to partners, and CAFF provided the structure, design, layout, and branding to support the guide production. This food guide launched the broader BFBL North Valley campaign that SCBGP funded. CAFF continued working with NCRLT to exchange ideas, lessons learned, and best practices in promoting California grown specialty crops across the North Valley region and Santa Clara Valley region.

Project Approach

After forming an advisory committee of 12 collaborators and developing the criteria for participation in the BFBL campaign, project staff contacted over 4,000 businesses (restaurants, farmers, distributors) to participate in the campaign over the course of the grant period. As a result, CAFF has grown regional participation in the campaign to 95 businesses since October 2012.

During the course of the grant period, eight school districts in Santa Clara Valley participated in the Harvest of the Month program; providing food service directors with materials for the cafeteria and educational tasting kits for the teachers to educate students about the featured fruit or vegetable.

In July of 2014, CAFF published the Buy Fresh Buy Local Guide for the Santa Clara Valley. 10,000 copies were distributed. The guide featured 40 farms, 35 farmers markets, 13 CSA's, 16 retailers, 7 wineries and 34 non-profit partners.

In September 2014, CAFF hosted a successful dinner to promote locally-grown food called the Taste of Santa Clara Valley. Nearly 100 people attended, and $17,553 was raised. The net profit of the California Department of Food and Agriculture (CDFA) portion of funding was reinvested in the campaign. Also in September, the Santa Clara County Board of Supervisors declared September "Local Food Month".

Project staff continue to provide technical assistance to the 95 farmers and businesses members and school partners through tools and events such as farmer presentation packets, growers wanted flyers, buyer/seller mixers and workshops, bus tours, availability lists, and the Harvest of the Month buying calendar. This technical assistance resulted in nearly 300 farm to market connections.

CAFF successfully advertised the BFBL campaign through bus ads and a three-month advertorial series with Bay Area News Group. The bus ad reached 144,081,300 people by running on 10 buses for 8 weeks. The readership of the advertorial was 1.1 million people in Alameda, Contra Coast, Santa Clara and San Mateo counties. In terms of digital performance, the three advertorials had a total of 297,873 ad server impressions and 1,195 ad server clicks.

The majority of the crops grown in Santa Clara County are specialty crops. The primary crops are mushrooms, peppers, nursery crops, and nearly $235 million of the county's $248 million in agricultural revenue is from fruits and nut crops, vegetables, floral and nursery crops. Non specialty crops and growers are not included in the BFBL SCV campaign; CAFF only worked with, featured, and supported buyers in purchasing from specialty crops growers in the Santa Clara Valley. The BFBL SCV label solely includes specialty crops grown in Santa Clara Valley: mushrooms, peppers, grapes, peaches, garlic, and tomatoes. The logo features cherries.

The BFBL guide and event did feature a small amount of non-specialty crop items grown by Santa Clara Valley producers such as beef and cheese. CAFF tracked and used other funds to support working with those growers and items. In the food guide, a majority of the listings were solely specialty crop growers or businesses, and the editorial pieces were 100% focused on specialty crops. Funding for the guide came from the grant and ad revenue. During the Taste of Santa Clara event, 73% of the food featured was specialty crops. The event was funded by the grant, ticket sales and sponsorships. The program was 100% solely focused on specialty crops. The portion of the net profits for the event resulting from grant funds was reinvested back into the BFBL Santa Clara Valley campaign.

CAFF formed many new relationships with partner organizations over the course of the grant period. Several of which are invested in the campaign's future and would like to see it continue. CAFF partners on this project include:

- Slow Food South Bay: advertised the campaign goals and helped with outreach to 20 restaurants.
- Santa Clara County Farm Bureau: promoted the BFBL SCV label, helped connect the campaign with their grower members, and wrote an article about the campaign in their newsletter.
- UC Cooperative Extension: helped connect with farmers and partnered with CAFF for the Farmer-Wholesale Bus Tour in November 2013.
- Santa Clara County Food System Alliance: helped to educate the County Board of Supervisors on the Local Food Month strategy by writing a letter of support to the board of supervisors. Helped promote the campaign to all of their non-profit members.
- School districts (Moreland, Gilroy, Sunnyvale, San Jose Unified, Oak Grove, and Mountain View-Whistman): participated in the Harvest of the Month program and increased local purchasing of specialty crops.
- New Leaf Community Markets: hosted production-planning meetings with local farmers and worked with CAFF to connect to growers to sell to their stores. They consistently utilize the Buy Fresh Buy Local branding in all 8 of their grocery stores.
- Coyote Valley Agricultural Enterprise and Conservation (COVAEC) Advisory Committee: supported and has helped promote the campaign. They are interested in continuing the BFBL campaign.
- The Health Trust of Silicon Valley: has been a supporter of connecting the campaign to healthy food access programs. CAFF advised the Health Trust on their Good.to Go. campaign, and how they can source from local farmers and distributors for their mobile fresh carts and grocery stores. They are also interested in continuing the BFBL campaign.

Goals and Outcomes Achieved

The measurable outcomes for this project were: 1) At least 75 businesses will join the BFBL campaign, and at least 15 of those businesses will increase their percentage of California grown specialty crops that they source, 2) At least 60% of students participating in education programs at 2 school districts will show an increase in knowledge of California specialty crops, and 3) At least 60% of focus group participants will indicate that the BFBL campaign influenced their purchasing decisions to buy California grown produce and will show increased knowledge of where their food comes from.

In order to achieve these performance goals and measurable outcomes, project staff performed the following activities: Established baseline data from 7 schools that CAFF worked with on this campaign; reviewed past purchasing records/invoices and collected purchasing data of chosen specialty crops from these schools each month. Staff provided HOTM marketing materials on one California specialty crop per month to these participating schools.

CAFF hired an evaluator who designed and distributed surveys to assess whether or not consumers' purchasing decisions were influenced by the BFBL campaign. The evaluator was also tasked with analyzing the purchasing data of 7 school districts that participated in the Harvest of the Month (HOTM) program, and designing tools for evaluating the impact of the Harvest of the Month campaign on students.

CAFF's goal was to accomplish the following activities: provide ongoing support to ensure monthly sourcing occurs, facilitate relationships between farmers and buyers based on the Harvest of the Month calendar, expand the BFBL directory, and convene business partners to share best practices, lessons learned and develop solutions surrounding sourcing local. The first two activities were completed and the last two were achieved but through a slightly different approach. Staff were unable to expand the BFBL directory because CAFF's website was being updated and staff realized that they were duplicating this service with another local agency. Staff have since entered into conversations with this partner organization about including Buy Fresh Buy Local branding in their extensive farmer directory. Although a formal convening of business partners to discuss local sourcing didn't happen, CAFF solicited individual feedback about best practices, lessons learned, and solutions to sourcing local. Staff used this information to create a strategy for continuing this work.

Overall, the project goal was to unite local businesses together through a county-wide 'Buy Fresh Buy Local - Santa Clara' (BFBL) marketing campaign that promotes California specialty crops and grows linkages between producers and consumers. Objectives to achieve the goal include: 1) Conduct outreach to Santa Clara County retail outlets, restaurants, worksites, and institutions to solicit participation in BFBL campaign; 2) Create a BFBL guide to market specialty crops in Santa Clara County; 3) Provide technical assistance to businesses interested in sourcing California specialty crops; 4) Launch a public education campaign to inform consumers about specialty crops and the benefits. Building these strategies together will foster an informed population of consumers educated about and engaged with the food system. CAFF achieved the goal and all objectives throughout the grant period. The first year focused on objectives 1 and 3 to build sales relationships and overcome barriers in getting California specialty crops into Santa Clara County businesses. The second year focused on promoting the growers and the specialty crops through a local food guide, which was published in June 2014, and launching a broad marketing and consumer education campaign.

Outcome 1: At least 75 businesses will join the Buy Fresh Buy Local campaign, and at least 15 of those businesses will increase the percentage of California grown specialty crops that they source.

CAFF kept a detailed account of all outreach, monthly local specialty crops purchases, and membership information in both Salesforce and in an Excel spreadsheet. The region's participation in the campaign has grown to 95 campaign members, exceeding the goal of 75 campaign members by 26.67%.

CAFF hired a Project Evaluator from San Jose State University who evaluated the Buy Fresh Buy Local campaign. Part of her evaluation was to analyze the purchasing data of 7 school districts that participated in the Harvest of the Month (HOTM) program. Of the total amount spent on fruits and vegetables, 36.1% was spent on locally-sourced fruits and vegetables, 9.8% was spent on fruits and vegetables sourced from California, and 54.1% was spent on fruits and vegetables from outside the state. The evaluator also interviewed 8 businesses other than school districts (distributors, restaurants, and grocery stores). All of the businesses reported a minimum of a 10% increase in local purchasing, half reporting a 25% or more increase.

Outcome 2) At least 60% of students participating in educational programs at 2 school districts will show an increase in knowledge of California specialty crops.

The Project Evaluator also analyzed the results of 1,081 student surveys to see if there was an increase in knowledge of California specialty crops. First through 7th graders completed a short matching quiz to assess their ability to identify various fruits and vegetables that were part of the Harvest of the Month (HOTM) program and associated classroom learning. Of the 11 items that the students were asked to identify in the survey, 72% correctly identified at least 9 items. Apples were correctly identified by 96% of all students making them the most correctly identified item. Green beans, cauliflower, radishes and avocados were correctly identified by over 90% of students, and kale, grapefruit, mandarins, and persimmons were correctly identified by over 80%. Fewer than 60% of students correctly identified dried pears and dried apricots.

Due to challenges in the evaluation collection and design, CAFF was unable to establish baseline data for this particular outcome. CAFF worked with outside evaluators who helped to administer surveys and analyze data through the HealthCorps service program. However, the results ultimately did not reflect changes in knowledge of California specialty crops, it focused on fruit and vegetable consumption. It also did not offer analyzed data for this project; they only provided raw data. The HealthCorps program ended in June 2014 and the evaluation team was no longer on staff after CAFF discovered the gaps.

To meet the evaluation goals, CAFF conducted another round of surveys asking about knowledge and analyzed them through another outside evaluator. No baseline was established as only one set of surveys was distributed. However, the results of the survey did show that 92% of the students surveyed exhibited knowledge of California specialty crops.

Outcome 3) At least 60% of focus group participants will indicate that the Buy Fresh Buy Local campaign influenced their purchasing decisions to buy California grown produce and will show increased knowledge in where their food comes from.

Section 3 of the Buy Fresh Buy Local Evaluation analyzed consumer attitudes to see if their familiarity with the Buy Fresh Buy Local campaign influenced their purchasing decisions to buy California-grown produce. Thirty-two shoppers at New Leaf Market in San Jose were surveyed, respondents were asked: “Was your decision to purchase produce influenced by the Buy Fresh Buy Local sign that you noticed?” followed by, “Did providing information about where the produce was grown influence your purchasing decision?” 53% of the respondents said that they noticed the BFBL signs, and that the signage influenced their purchasing choices. The small number of respondents may not be representative of all New Leaf shoppers. For some specialty crop items, there was not a locally sourced choice with signage, so it is difficult to determine how much the slogan impacted consumer decisions.

Major successful outcomes of the project include:

- 95 businesses joined the Buy Fresh Buy Local campaign over the course of 2 years. Each of these businesses received assistance in promoting, buying, or selling CA specialty crops.
- At least 8 businesses increased the percentage of California specialty crops procured throughout the project period.
- 72% of students in participating schools increased their knowledge of California specialty crops.
- 53% of consumers surveyed said that the Buy Fresh Buy Local campaign influenced their purchasing decisions.

- 10,000 copies of the Buy Fresh Buy Local Guide for the Santa Clara Valley were distributed, promoting California grown specialty crops from the region.
- At least 300 sales connections were established for specialty crop farmers and buyers, resulting in at least $544,986 in sales.
- $17,553 was raised through the first annual Taste of Santa Clara Valley dinner in September, 2014. Net profits from the grant portion of funding have been reinvested into the campaign

Beneficiaries

The groups and other operations that benefited from the accomplishments of this campaign include:

- Specialty Crop farmers – received sales and marketing support, including increased sales of specialty crops
- Businesses and other buyers – established connections with specialty crop growers and received support in marketing locally sourced specialty crops,
- Students – increased their awareness of California grown specialty crops
- Non-profit partners – offered sales and marketing to specialty crop growers and coordinated consumer education efforts through collaboration on the Buy Fresh Buy Local campaign

In the BFBL evaluation, businesses (other than school districts) were asked if the total dollar amount of their local purchases increased since participating in the BFBL campaign. Eight respondents indicated their local purchases increased. Three of the eight indicated purchases increased less than 5%; two indicated an increase between 5% and 10%; one indicated an increase between 25% and 50%, and 2 indicated an increase between 50% and 75%. Four respondents noted that they did not know if the dollar amount of their local purchases increased. Farmers were asked if the total dollar amount of their local sales increased since participating in the BFBL campaign. Of 16 respondents, nine indicated "yes," two indicated "no," and five did not know. Among farmers that noted an increase in sales, two noted sales increased less than 5%, five noted an increase between 5% and 10%, and two noted an increase between 10% and 25%.

As a result of the technical assistance and frequent communication with farmers, produce distributors, food service staff and directors, at least $544,986 has been spent on specialty crop produce from farmers living with or around 150 miles of Santa Clara Valley. While this data reflects what staff have been able to capture from 15 buyers (8 businesses and 7 school districts), the economic impact is much greater beyond what staff were able to measure.

Lessons Learned

In concluding the work on this campaign, CAFF can provide several insights:

1) Staff realized that they needed to budget more money for a robust evaluation of a broad campaign such as this one and its outcomes. The small sample sizes, number of evaluation strategies, broad nature of measuring the impact of consumer education, and lack of adequate funds allocated to evaluation contributed to an evaluation staff felt could have been more effective in measuring the campaign's impact. More resources and funding would have helped with these issues.

2) Due to staff turnover over the course of the grant, CAFF realized how important it is to leverage partnerships and to maintain relationships. CAFF had a fair amount of project staff leave over the last two years, and saw how it affected the maintenance of these relationships and ability to advance campaign goals.

3) Most importantly, staff found that the technical assistance to farmers and businesses was more valuable than the BFBL branding (logo, etc.). Staff could have spent the entire grant on helping farmers with sales and supply chain logistics in accessing the various markets introduced to them. While it's important to couple the sales with consumer marketing, staff struggled with creating recognition of the BFBL brand in this broad of a region due to scale and resources. It takes substantially more money and time to have a lasting impact on changing consumer behavior. For example, staff estimated a billboard to cost $3000 but found that the true cost was actually $5000 for 4 weeks.

CAFF had several unexpected outcomes as a result of implementing the BFBL campaign. Although distributors were enthusiastic to sign on to the campaign initially, it was challenging to work with local distributors in creating transparency and maintaining source identification throughout the supply chain. Understanding their systems and processes was difficult and advocating for transparency and identifying local produce being purchased proved very difficult. Their systems did not allow for them to track data on sourcing easily, and they were unwilling to change their systems to identify the volume and dollar amount of California grown specialty crops purchased by buyers on the project.

In terms of outcome measures that were not achieved, staff were only able to analyze the data from 7 schools instead of the 15 businesses stated in the Performance Monitoring Plan. It proved challenging to collect financial and sourcing information from the other buyers. This is due to 1) businesses not tracking purchasing data or unwilling to share financial information and 2) the inability of distributors to provide reports tracking buyers' purchases by farm and farm location. Only some distributors, such as Watsonville Coast Produce, have adapted their systems to provide the level of information needed to assess the amount of Santa Clara Valley specialty crops purchased. The challenge lies in the software systems as well as designating storage for each item by farm and farm location in the warehouse. CAFF will continue to work with distributors to break down this barrier beyond the grant period.

Additional Information

See Attachement 1: Buy Fresh Buy Local Guide for the Santa Clara Valley

USDA Project No.: 7	Project Title: Consumer Education – California Bountiful Television Program	
Grant Recipient: California Bountiful Foundation	**Grant Agreement No.:** SCB12007	**Date Submitted:** December 2014
Recipient Contact: Dave Kranz	**Telephone:** 916-561-5550	**Email:** dkranz@cfbf.com

Project Summary

This project addressed the need to provide information to people in California's largest cities about the health benefits and availability of California-grown fruits, vegetables, nuts and other specialty crops. The California Bountiful television program specifically addressed this need by providing information in an entertaining, fast-paced manner that introduced viewers to the farmers, marketers, chefs and other people involved in growing and preparing healthful specialty crops.

At a time of concern about food deserts and healthy diets, and a time of great interest in the source of food, Californians need information about the availability of locally grown specialty crops and about who grows, markets and prepares them.

This project built upon 2011 SCBGP Project 8. Through that project, California Bountiful produced specialty-crop-themed, half-hour programs that aired 34 times during 2012 and the first quarter of 2013 on television stations in Los Angeles, San Francisco, San Diego, Sacramento and Monterey/Salinas. On those stations, the 34 programs reached more than 1.86 million viewers. This project allowed continued broadcast of specialty-crop-only television programs in the same television markets, to complement the previous project.

Project Approach

In October-December 2012, the Media Planner determined the cost and availability of airtime on television stations and, in December 2012, the California Farm Bureau Federation, on behalf of the California Bountiful Foundation, agreed to air the California Bountiful program beginning in January 2013 on KCAL, Los Angeles, Saturdays at 7:30 p.m.; KRON, San Francisco, Fridays at 11 a.m.; KUSI, San Diego, Sundays at 10:30 a.m.; KXTV, Sacramento, Fridays at 2:30 p.m. (with a second airing Saturdays at 5:30 a.m.); and KSBW, Monterey/Salinas, Fridays at 12:30 p.m.

The Project Manager developed a schedule of programs that included 15 programs featuring specialty crops exclusively, with each program to be aired twice.

The Project Manager oversaw production and scheduling of each weekly program, and worked with the affiliated television stations to produce promotional messages that appeared on air and on station websites. The Media Planner collected overnight ratings data in the four markets for which such information was available (Los Angeles, San Francisco, San Diego and Sacramento), and worked with the Project Director and Project Manager to analyze the data and evaluate viewership patterns.

The Web Specialist collected and analyzed data for the California Bountiful website and social media channels (the website and social media sites also incorporate content from California Bountiful magazine).

With the project duration extended to March 2014, and after consultation with the Media Planner, CFBF agreed to a revised station lineup for the first quarter of calendar year 2014: KCAL, Los Angeles, Saturdays at 7:30 p.m.; KPIX, San Francisco, Saturdays at 7 p.m.; KUSI, San Diego, Sundays at 10:30 a.m.; and KXTV, Sacramento, Sundays at 4:30 p.m. (with a second airing Saturdays at 5:30 a.m.). Four additional specialty-crop-only programs would be aired on this network in January-February 2014 in order to spend remaining funds.

During the grant period, California Bountiful also produced programs that featured both specialty crops and other crops; airtime for those programs was paid for by the California Farm Bureau Federation exclusively. Project Manager and Project Director assured that grant money for airtime was directed only to specialty-crop-only programs, and that travel and retention of freelance videographers billed to the grant involved exclusively the production of program segments devoted to specialty crops.

Goals and Outcomes Achieved

During the grant period, California Bountiful produced 15 half-hour television programs devoted exclusively to specialty crops, and aired each program twice on its network of affiliated television stations. The Project Manager conducted special on-air appearances on affiliated stations to promote specialty crops and to encourage viewership of California Bountiful. In addition, each affiliated station broadcast on-air promotional messages encouraging viewers to watch California Bountiful, and each placed promotional banner advertisements on their websites. California Bountiful also promoted the program via its own social media sites and in advertisements in *California Bountiful* magazine and in the California Farm Bureau weekly newspaper, *Ag Alert*. Full content of each California Bountiful television program was also made available online via the California Bountiful website.

California Bountiful achieved the goal of producing 15 television programs devoted exclusively to specialty crops, and of airing each program twice during the grant duration. Due to two changes in the network of affiliated stations that took effect in January 2014, and of subsequent preemptions of the program by the new San Francisco station, the specialty-crop programs aired a total of 27 times in San Francisco during the grant period and a total of 26 times in Monterey/Salinas; the full 30 specialty-crop programs aired on the affiliated stations in Los Angeles, San Diego and Sacramento. On the stations where airtime was purchased through the grant, the 30 specialty-crop programs reached a cumulative audience of 1,641,705 viewers.

During the previous project in calendar year 2012, California Bountiful established baseline data by producing 15 programs devoted exclusively to specialty crops and airing each program twice, for a total of 30 airings on the affiliated stations. Nielsen television ratings provided by the affiliated stations indicated that those 30 programs attracted a total audience of more than 1.6 million viewers. The first grant project also supported the airing of four additional specialty-crop-only programs in the first quarter of calendar year 2013; those programs attracted a total audience of approximately 224,000 viewers. The total viewing audience for the 34 programs exceeded 1.86 million people, or an average of 54,706 viewers per week on the stations where viewership could be monitored. Project managers also measured traffic to the California Bountiful website at www.californiabountiful.com as an additional gauge of viewer interest (the website contains content from both the television program and California Bountiful magazine). During 2012, unique visitors to the California Bountiful website increased 36 percent and total visits increased 36 percent, when compared to the previous year.

The 30 specialty-crop-only television programs produced by California Bountiful reached a total audience of more than 1.64 million viewers in California during the grant period, or an average of 53,824 viewers per week. Viewership in Los Angeles totaled 568,961; in San Francisco, viewership totaled 224,006; in San Diego, viewership totaled 496,883; in Sacramento, viewership totaled 295,800; and in Monterey/Salinas, viewership totaled 56,055.

Visits to the California Bountiful website increased in 2013 when compared to 2012. The number of unique visitors and of total visits each increased 26 percent. Participation in California Bountiful social media also rose during 2013. The California Bountiful Facebook page saw its number of fans nearly double in 2013, increasing 92 percent during the year.

Beneficiaries

This project benefited the full range of California specialty crop farmers by extending an outreach effort that introduced urban and suburban residents to family farmers and showed how specialty crops are grown and marketed. It reached an audience that farmers have frequently expressed a desire to reach: the people who live in the state's largest cities and nearby areas. Viewers of the program also benefited, by learning more about the variety and nutritional benefits of California-grown specialty crops and by learning new ways to prepare and enjoy those crops.

The project benefited the tens of thousands of specialty crop farmers in California. Television programs supported by the project also reached a quantifiable viewing audience of more than 1.64 million people during the course of the project. The actual audience for the programs was much larger, although not quantifiable, because California Bountiful also airs on dozens of broadcast and cable stations in California that do not gather ratings information for the program.

Lessons Learned

In purchasing television airtime for the specialty-crop-only programs, the project team learned the importance of affiliating with the strongest possible stations to achieve the highest possible viewership. The program established strong and successful ties with affiliated stations in Los Angeles and San Diego, but audiences were smaller in San Francisco or Sacramento. In some cases, that appeared to be due to changes in the on-air programming that preceded or followed California Bountiful on those affiliates; in others, it appeared due to relatively weak overall performance by the station itself. Project Manager and Media Buyer adjusted the schedule of California Bountiful as best as possible in those markets to achieve higher audience numbers; affiliates in San Francisco were shifted in January 2014 and eliminated the Monterey/Salinas affiliate at the same time in order to be able to afford more expensive airtime on the larger San Francisco affiliate.

Because of the shift in San Francisco affiliates in January 2014, and because the new affiliate unexpectedly preempted California Bountiful on three occasions that month, the specialty-crop-only programs aired in San Francisco only 27 times during the grant period. From this experience, project staff learned the importance of establishing relationships with personnel at new affiliated stations as early as possible after airtime commitments are finalized. Had the program aired all 30 times in San Francisco, California Bountiful would certainly have achieved higher average viewership figures during this project than for the comparable programming in 2011 project #8; as it was, the average weekly audience for programs produced under this project came within 1.6 percent of matching the average achieved in 2011 project #8.

It is imperative to have each person know exactly what their task is and to have a procedure in place to ensure everyone understands the proper work flow. This is especially true when multiple employees work on one project, as was the case here. It is essential to have appropriate checks and balances in place and to have proper documentation; this streamlines project operations and is especially valuable during the audit process. A willingness to adapt to unexpected changes is another must. A grant must be thought of as a living entity, in which project managers must be flexible and adapt to unforeseen circumstances in order to achieve the desired outcomes.

USDA Project No.: 8	Project Title: Avocado Grower Training for Spanish Speakers	
Grant Recipient: California Avocado Society	**Grant Agreement No.:** SCB12008	**Date Submitted:** December 2015
Recipient Contact: Jim Davis	**Telephone:** 760-747-2920	**Email:** jim.davis@americansectaries.com

Project Summary

Spanish speaking farm workers and growers have lacked access to information to help make them be successful in the production of avocados, which are California Specialty Crops. The California Avocado Society (CAS) would create an agricultural outreach program to provide technical education that gives critical job skills to a group that has little formal education, in an effort to improve the competitiveness and sustainability of California avocado producers. This project would have addressed this issue in three ways: Provide seminars in Spanish language for farm workers and growers; offer simultaneous translation for Spanish speakers at the CAS ongoing Grower Seminar Series; and translate printed material that had been produced by the CAS and others. The purpose of this effort was to improve the decision making by Spanish speaking farm workers and growers to increase the avocado production.

Exponential increases in water costs and decreasing water quality have made increasing production efficiency vital for avocado growers to remain profitable. Avocado production acreage has been decreasing as costs increase; therefore, this project was one part of the industry effort to increase productivity on a per-acre basis.

This project did not built on a previously funded Specialty Crop Block Grant Program funded project.

Project Approach

The most significant components of the project was the seminars given in Spanish language. These were designed to imitate the CAS's Grower Seminar Series, where a topic is presented in three locations (San Luis Obispo, Ventura, and Fallbrook of California) to accommodate growers in the whole range of avocado production. The first two topics were Pest Control and Irrigation. The third presentation, Fertilization and Soil Fertility, was only made in Fallbrook, California as the main presenter was unable to travel to the other cities.

The second component was the simultaneous translation of the Grower Seminar Series in Spanish language. At the first seminar series, it was noted by the University of California Cooperative Extension (UCCE) personnel that the room was so small the simultaneous translation noticeably interfered with the ability of the English speakers to hear the seminar presenters. After several discussions about possible alternatives, project team has decided to stop the translations in San Luis Obispo, California and use equipment to offer translations in Ventura and Fallbrook, California. Unfortunately, no seminars in these two northern cities were translated after the first series. Three Grower Seminar Series meetings, held in Temecula, California were successful in simultaneous translation by using equipment rented for that purpose.

The third component was translating already produced information by the CAC and others. No progress was made on this component.

This project only served to enhance California specialty crops. All trainings were aimed at avocado growers. The most significant contributions by project partners were made by the UCCE personnel. They were expected to develop the curriculum, test quizzes, make presentations at the seminars, as well as advertise the seminars. For the three seminars series that were presented, the UCCE developed the curriculum for one topic (Irrigation) and presented the seminar for that topic. Most of the communication by the project members was conducted by teleconference calls; the UCCE partners actively participated in these calls, which covered such planning topics as finding presenters, seminar dates and locations, and seminar topics. They also helped produce the advertising flyer for two seminars (Irrigation and Fertilizers).

The partner at the University of California, Riverside (UCR) helped plan and present the first seminar: Pest Control.

Goals and Outcomes Achieved

Project team have created a list of seminar topics for the Spanish speaking-only seminars, listed potential presenters, reserved seminar locations, created curricula for three topics, created quizzes for the three topics, and advertised the seminars. Seven seminars were held on three topics, before and after quizzes were conducted, and videotaped one seminar on each topic.

Simultaneous translation into Spanish was provided for five of the CAS's Grower Seminar Series presentations, one in Ventura and San Luis Obispo, and three in Temecula, California.

The project's outcome measures were short term. Project team conducted topic knowledge quizzes before and after each of the seven seminars to assess any improvement of topic understanding gained from the seminar.

Project team set out to hold thirty seminars for Spanish-speaking fieldworkers, simultaneously translate thirty seminars in the English-speaking Growers Seminar Series, and translate useful publications made by the California Avocado Commission (CAC) and others into Spanish language. Seven seminars were held for Spanish-speaking fieldworkers, and translated five seminars in the English-speaking Growers Seminar Series.

Project team gave an identical quiz at the beginning and end of each Spanish-speaking seminar. Measurement was set to measure the difference in score between first and second quiz. More than half of the questions were answered incorrectly on the first quiz, but answered all correctly on the second quiz. Overall seventy-four percent of the students met the criteria of passing the second quiz.

Overall, ninety-nine Spanish-speakers attended the seven seminars that were given. Of those, sixty-nine returned quizzes that were gradable. All twenty-three quizzes from the first seminar in Ventura, California were improperly completed and not useable. The two seminars in San Luis Obispo, California had no attendees. In the four remaining seminars, the percentage of students who met the criterion were sixty-nine, seventy-nine, eighty-three, and thirty-three percent. Of the sixty-nine graded quizzes, all students showed improvement in their test scores except one student, in each seminar, showed a decline in quiz score; and one student in one seminar had the same pre and post seminar score.

Beneficiaries

Project team set out to educate field workers who work in small groves about the basics of growing avocados. Many field workers showed interest, but most of the attendees in the Fallbrook, California locations were foreman and employees of larger farms. The owners of these larger farms were surprised and pleased at the enthusiasm the workers had for the seminars, and the knowledge they gained. The comments by the attendees were also very positive, often asking when the next seminar would be held. One field worker commented that "We are always told what to do, but never told why. Here I am able to learn why."

Only a few people took part in the simultaneous translation of the Growers Seminar Series; they were primarily grove owners and farm managers.

The Spanish-speaking seminars were attended by ninety-nine people. It is expected that the knowledge gained by the participants will improve the decision making on the farms where they work, and may be multiplied by the foremen and farm managers that pass the instruction on to the people who work for them. If each of these people are able to increase the productivity of the farms where they work by five percent over the industry average of 6,000 pounds per acre, the economic impact would be approximately $30,000.00. This does not include bringing awareness of this information by the foremen and farm managers or by the distribution of the seminars on DVDs.

Lessons Learned

The project was terminated because the project goals could not be completed and therefore, the expected measurable outcomes could not be achieved. There were many lessons learned throughout the duration of this project. In the initial planning phase of the project, there should have been concrete tasks and deadlines for the individual members of the team to be responsible for; project team individuals would know what was expected of them and it would have prevented the confusion of who was supposed to complete what task. With better planning and communication, the project team, collectively, could collaborate together to complete project goals. In addition, due to conflicting commitments, the Project leader and the California Avocado Society's Executive Administrator were often the only ones to conduct the project activities. Adequate project staffing would have allowed tasks to be distributed and ensured project completion.

Communicating in-depth with the project team about their views on the need for the program and the likely target market for the program in their area of influence, is a crucial part in understanding and delivering goals on schedule. Had there been an in-depth conversation and analysis with each project member, it might have been recognized that only a few people were likely to attend the Spanish-speaking seminars in the San Luis Obispo county area of California. Having a full staff and support from collaborating organizations would have landed more help and time in conducting the site visits in Ventura and San Luis Obispo, where the Grower Seminar Series were presented; therefore it would have reduced the difficulty of doing simultaneous translation in the small venues.

On the positive side, the project team was successful in video recording each of the three Spanish-speaking seminars in Fallbrook, California so that the DVDs can be produced with the seminars for distribution to workers who were unable to attend the seminars in person. Producing the videos was an alternative to conducting live seminars in an effort to meet the project expected measurable outcomes. These three are arguably most important areas to be covered by the seminar series: Irrigation, fertilization, and pest control.

USDA Project No.: 9	**Project Title:** Honey Bee Best Management Practices	
Grant Recipient: Project Apis m.	**Grant Agreement No.:** SCB12009	**Date Submitted:** December 2015
Recipient Contact: Christi Heintz	**Telephone:** (520) 834-2832	**Email:** christih@cox.net

Project Summary

This project raised awareness of honey bee Best Management Practices (BMPs) through an easily accessible social media campaign. Honey bee BMP outreach via a social media campaign enabled dissemination of best practices to a wider audience than a traditional print media campaign would be capable of reaching. The outreach program ensured wide-spread dissemination of best practices information to assist beekeepers to maintain a healthier bee supply. Instant access to web-based information on honey bee pest and disease control, nutrition, hive management, colony management and taking steps to mitigate transportation and pesticide stress is vital not only to beekeepers, but also to growers who rely on healthy and strong honey bee colonies to pollinate their crops. Emphasis was placed on social media networks, blogs, and content communities; including internet-based development of a Facebook presence, Twitter dialogue, video blogging and YouTube content. Using these formats for social media, beekeepers had instant access to BMPs to better manage their bees. Growers of California's specialty crops also had instant access to information about protecting honey bees to ensure maximum pollination of their crops.

This project was important due to the concern about significant colony losses associated with Colony Collapse Disorder (CCD), increased over-wintering colony losses, and decreased longevity of worker bees. United States Department of Agriculture (USDA) scientists identify the cause of CCD as being multifactorial, i.e., caused by many different factors including pests, diseases, pesticides and poor nutrition. Thus, approaches to combating CCD, over-wintering losses and decreased lifespan of honey bees must be multifactorial approaches. This BMP program provided a many-pronged approach to ensuring bee health. BMPs addressed Varroa mite, Nosema disease, building nutrition and honey bee habitat, and colony management and transportation. Because more people, including beekeepers and growers, are using internet-based technologies to obtain information, this project was timely and fulfilled a need to have more BMP information available on the Web. Beekeepers, and growers who rent bees to pollinate their crops, need relevant, real-world examples of BMPs that work. Social networking platforms provide low-cost, easy-to-produce, easily accessible formats to provide information about practical issues from experts in the field.

This project built upon 2009 Specialty Crop Block Grant Program Project 1: *Best Management Practices for Honey Bees Pollinating California's Specialty Crops,* wherein BMPs were developed and dissemination of materials was initiated. The previous project identified five areas for BMP development, and an outreach campaign was initiated. Response to the materials was excellent, and opportunities to further develop and promote BMPs were bountiful. Updating current information, developing new BMPs, and disseminating the information in new updated formats was essential for building stronger honey bee colonies and providing adequate honey bee supplies to sustain a pollination industry supporting California's specialty crops. The new BMP project expanded the current communication campaign using social electronic media tools to reach more beekeepers and more growers of California's specialty crops.

Project Approach

The work plan consisted of administrative tasks (preparing contracts, policies and procedures, invoices and biannual reports), reviewing, refining and updating BMPs based on recent literature and publications and research presented at scientific meetings, building and updating a BMP website, developing and expanding social media tools such as Twitter and Facebook, and producing videos for posting on YouTube. Additionally, outreach on BMPs was performed by presenting the information via PowerPoint presentations and in trade show booths at regional, state and national meetings.

Undertaking the project required an initial assessment of the status of current BMPs and current methods of information dissemination. Also, beekeepers were surveyed for their familiarity with BMP terminology. The various methods for utilizing social platforms were evaluated, and four methods were pursued: 1) a website, 2) Twitter, 3) Facebook and 4) YouTube. Additionally, means for measuring engagement within the context of these platforms were established. Finally, baseline measures for bee health were assessed at the beginning of the project, annually, and at the end of the project.

Benchmarks were established during the initial months of this project. Those benchmarks included: 1) number of enewsletter subscribers, 2) videos produced, 3) website hits on the Project Apis m. (PAm) BMP tab, 4) beekeeper familiarity with BMP terminology, and 5) beekeeper familiarity with social media tools such as Facebook and Twitter.

Thirty monthly enewsletters were published during this grant period. Each enewsletter featured one or more seasonally-appropriate BMPs. Subscribers for the enewsletter increased from 400 to 1,615 during the project period. Open rates and the most popular content were tracked and recorded. For two years in a row the enewsletter received “All Star” status by demonstrating exemplary engagement with the target audience and setting a standard of excellence. Open rates for the enewsletter averaged 40%, well above the industry average of 15-25% open rates for enewsletters.

Views and subscribers on YouTube videos were also established and tracked for the duration of the project period. There were a total of 18 videos monitored, 14 of which were produced during the project period. These videos and their view rates were as follows: Varroa BMPs (16,282 total views, compared to 7,168 views at the start of the project), Nosema BMPs (2,972 views, with 198 views initially), Nutrition BMPs (993 vs. 165 initial views), and Transportation BMPs (ranked as the most viewed video with 26,177 views, up from 365 initial views). The new videos produced under this project included the BMP Video (232 views), Bee Forage Field Day (209), It’s All about Forage (600), Plan Now for Pollination (131), Varroa - The Take Home Message (318), AgNet TV Forage Project (168), Pollinating Crops - Time to Pollinate Almonds (192), Seeds for Bees (385), A Drone’s View of Bee Pasture (554), Modesto Bee Heintz/Silveira (448), A Bee’s Eye View (66), Planting a Cover Crop - For the Bees (314), Planting a Cover Crop - For the Grower (132), and Bee Informed Partnership Tech Transfer Teams (5). Grand total of YouTube video views were 50,178, and total YouTube subscribers increased from zero to 163.

The Project Apis m. website was completely overhauled and updated from Joomla to GoDaddy with blogging opportunities added. This conversion allowed for much greater flexibility in keeping the information up-to-date. The BMP tab was expanded and updated to reflect the most current BMP information. The BMP tab received over 7,000 hits since October 1, 2012, the start of the project period. Typical BMP tab website hits prior to October 1, 2012, were about 125 per month and grew to an average of >250 hits per month by the end of the project period. Collaboration also was undertaken with related organizations to expand BMP information via links. Bee Informed Partnership (BIP), Western Apicultural Society (WAS), American Beekeeping Federation (ABF), and Honey Bee Health Coalition (HBHC) are a few examples of organizations and websites that provided links to Project Apis m.'s website. California Department of Food and Agriculture's (CDFA) Plant Health and Pest Prevention Branch facilitated the development of greater web presence and information at Border Protection Stations.

In a survey of beekeepers for familiarity with the term "BMPs," 20% of beekeepers were familiar with BMPs at the onset of the project. By project end, 70% of beekeepers surveyed understood the term "BMPs." An initial survey found no beekeepers in an audience of 100 beekeepers using Twitter. By the completion of the project, Twitter followers had increased from zero to 142. Surveying a regional beekeeper meeting with 60 participants, only 5 individuals used Facebook. At the end of the project, Facebook followers grew from zero to 808. New posts occurred at least monthly on Facebook and/or Twitter.

Both electronic and print materials highlighted BMPs to engage beekeepers and the grower community via social media methods and traditional means and involved an effort to afford great access to information on bee management and health. Five thousand five hundred BMP brochures and 2,500 one-page fact sheets covering various individual BMPs were distributed during the course of this project.

Other print media promotions of honey bee BMPs included bimonthly articles in Blue Diamond's Almond Facts Bee Box and articles in Growing Produce, the Modesto Bee, the Fresno Bee and the Bakersfield Californian, California Almond Outlook, CSR Wire, Western Farm Press, WAS Journal and California State Beekeepers Bee Times. Work was conducted with the Almond Board of California to produce and edit articles on fungicide and insect growth regulators use and Nosema/fungicide interactions. The Honey Bee Health Summit was covered by numerous publications, including Barron's, UC Apiaries News and The Grower. The California Farm Bureau covered honey bee nutrition and forage in Ag Alert. An article in The Pacific Nut Producer highlighted Nickels Field Day and honey bee nutrition. Two CDFA videos on honey bee forage were highlighted in Planting Seeds. The Western Farm Press carried articles on Colony Collapse Disorder and also highlighted the CDFA videos. AgNetTV twice featured the project manager discussing BMPs. Western Farm Press also featured a Bee Biologist discussing BMPs.

Regional, state and national meetings were attended for information on the latest scientific findings that had relevance for practical improvements in BMPs for beekeepers. Pest, Disease, Colony, Hive and Business Management BMPs were updated with input from the Honey Bee Health Summit (HBHS), and BMPs were linked to the Bee-Informed Project (BIP) National Management Survey videos. Transportation BMPs were updated with the publication of a revised brochure with the latest information on border crossing, soaker hose additions to truckloads, and hosebib availability at border stations. "A Guide for Honey Bee Colonies Entering California" was revised and printed in a third printing. Nutrition BMPs were expanded to emphasize the importance of diverse natural forage in building strong honey bee colonies and mitigating pests, diseases, pesticide and transportation stress. Grower BMPs were refined in cooperation with the Almond Board to incorporate the latest information on pesticide tank mixing and the importance of nighttime sprays to protect bees. Effort was given to the promotion of BIP Tech Transfer Teams as "crop consultants" for beekeepers for Varroa and Nosema testing. Also, a new area of BMP development included Grower BMPs to protect honey bees from fungicide sprays and, particularly, tank mixes of fungicides and insect growth regulators (IGRs).

Another BMP area of emphasis included providing adequate water for bees, given the lack of California rainfall over the past several years.

A total of 44 presentations were given during the grant period to promote honey bee BMPs and ways to access BMP information through traditional and social media formats. All regional and national meetings and the number of attendees at the presentations, as well as visitors to the trade show booths, are included in (Attachment 1). In summary, the total audience reached was 3,882 people via presentations and 12,650 people via trade show booth visits; with a grand total of 16,532 people reached. Additionally, materials were provided to the California State Beekeepers Association (CSBA) for distribution at the Los Angeles County Fair.

The most effective traditional and social means of outreach for BMPs to beekeepers and for growers renting bees for pollination of their crops would include: 1) presence at beekeeper and grower meetings to promote BMPs by being a featured speaker and having a trade show booth, 2) use of meetings to demonstrate how to access BMPs on the web, 3) articles in local newspapers, agricultural and bee journals, 4) up-to-date information provided via the internet using a website or webpage dedicated to honey bee BMPs, 5) monthly, seasonally-based BMP features in an enewsletter, and 6) frequent Facebook posting to access those not reached via live presentations or an established webpage. Twitter was found not to be as popular among the target audience and was also limited in its ability to portray real information.

It is recommended that provocative presentation titles, article titles, and enewsletter subject lines be employed to draw attention to the BMP message. Visual means should be fully utilized. Good quality, colorful photographs in enewsletters and in PowerPoint presentations draw greater attention to the material being presented. YouTube videos with a strong, relevant message and interesting, high-quality videography are an increasingly popular method of learning.

BIP managers completed and published the over-wintering loss survey and managed Tech Team analyses of pest and disease practices, contributed information from a comprehensive Management Survey to improve on Varroa and Nosema BMPs, and developed videos explaining the data collected and how beekeepers can use the information in their own operations. They also directed the annual BIP meeting, reviewed data from the annual Honey Bee Management Survey, and solicited input for additions to the 2015 year survey. The BIP Team related responses from the Survey to colony health and thus derived a list of management practices designed to minimize honey bee losses. This information served to refine the BMPs promoted in the project outreach program. The University of California, Davis, Extension Apiculturist published a bi-monthly newsletter (posted to Project Apis m.'s website) on honey bee health and management that closely dovetailed with this BMP project and spoke about BMPs via media outreach opportunities. The CSBA provided opportunities in their enewsletter and at their annual convention to promote BMPs. Both CSBA and the Almond Board of California (ABC) were instrumental in refining grower BMPs to protect honey bees during almond bloom and relayed BMPs to California beekeepers and California almond growers. Paramount Farming, Inc.'s Bee Biologist provided oversight to the project, delivered presentations on BMPs for honey bees using information from this project--specifically at the Florida State Beekeepers meeting, and assisted in the production of videos. The Bee Biologist was also the primary subject of two videos produced and a Western Farm Press article.

Goals and Outcomes Achieved

The project reached the measureable outcomes of: 1) translating the most recent research into real-time practical management techniques, 2) improving existing BMPs and adding pertinent new areas, 3) maintaining traditional print outreach materials, 4) expanding web-based outreach mechanisms, 5) developing social media opportunities, and 6) developing measures for the social media campaign.

Activities completed to achieve the performance goals included: 1) assessing the status of BMPs at the start and completion of the project, 2) surveying beekeepers as to their familiarity with BMP terminology at the beginning and end of the project, and 3) monthly monitoring and recording BMP website, Facebook, Twitter and YouTube hits, enewsletter and subscriber data, attendees at BMP presentations and trade show booths, articles, brochures and fact sheets.

Participation in regional, state and national bee meetings provided the opportunity to both receive the latest information on BMPs to refine outreach materials and to distribute BMP guides and articles in traditional print format. The most widely distributed print materials during this reporting period included two beekeeper guides: "A Seasonal Guide: BMPs for Beekeepers Pollinating Almonds," and the transportation brochure: "A Guide for Honeybees Entering California." These two brochures were continually updated as well as distributed at beekeeper meetings. For growers, "Best Management Practices for Almond Growers" was distributed to an audience of 2,500 growers. Traditional print media distribution reached over 250,000 with 10 Almond Facts articles, three Western Farm Press articles and numerous other media hits. Since the inception of the project, 5,500 brochures and 2,500 one-page fact sheets were distributed.

Web-based and social media outreach opportunities expanded exponentially and measures to assess outreach were in place. ENewsletter subscribers, video viewers and subscribers, Twitter followers, Facebook "Likes" and website hits were enumerated monthly. Compared to baseline data at the beginning of the grant, Facebook "Likes" increased from zero to 808, and Twitter followers from zero to 142. Views of the Varroa BMP video increased by 227% compared to the baseline value. Views of the Transportation BMP video increased by over 70-fold. With the Varroa video being highly viewed, a second Varroa video was produced. BMPs were expanded with more outreach on protecting bees from pesticide sprays.

This project far surpassed expectations. The overall goal was to provide the latest information to beekeepers and to improve honey bee management practices. In-person PowerPoint presentations were particularly effective, reaching an audience of 3,882. One specific objective for the grant included attending one state, one national and one grower meeting per year to promote BMPs. By the conclusion of the grant, 44 total presentations were made due to the numerous requests for BMP presentations. These speaking opportunities included four grower meetings, eleven regional meetings, nineteen state meetings and ten national meetings. Beekeepers pollinating California's specialty crops bring bees to California from all over the nation. BMP presentations were requested in Oregon, Idaho, Montana, Wyoming, Colorado, North Dakota and Florida--all important states when it comes to the transporting of honey bee colonies to California for pollination. The BMP project received national exposure at the American Honey Producers and the American Beekeeping Federation, also meetings attended by our nation's migratory beekeepers. In addition, the project was highlighted at other national meetings, including the American Bee Research Conference, the Entomological Society of America, and a USDA Summit on Forage and Nutrition.

Trade show opportunities reached 12,650 individuals, with many more hobby beekeepers reached via materials presented at the Los Angeles County Fair.

Eight video blogs were scheduled to be produced, and this goal was exceeded, with 14 new videos produced and over 50,000 views of the project's honey bee BMP videos. Views of the Varroa BMP video were more than doubled compared to the baseline value while views of the Transportation BMP video increased by over 70-fold.

While many individuals prefer traditional print outreach materials (and these were provided for regional and state meetings), web-based outreach was effectively measured and reached a far greater audience. Monthly enumeration of web-based outreach activities indicated an increase in all YouTube videos produced, BMP tab hits, and other web-based media.

At the onset of this project, YouTube, Facebook and Twitter presence was non-existent. By the end of this grant period, there were a combined number of 50,178 views on all videos to date, 163 YouTube subscribers, 142 Twitter followers and over 1,600 enewsletter subscribers. An enewsletter was produced each month (30 total), and each month seasonal BMPs were highlighted. Open rate on enewsletters remained over 40%, far surpassing the average enewsletter open rate for non-profit organizations of 27%, qualifying Project Apis m. for "All Star" status.

Research, beekeeper and grower feedback enabled continued refining of practical BMPs. The seven original BMP areas (Varroa, Nosema, Nutrition, Hive Management, Colony Management, Business Management and Almond Grower BMPs) were each improved. For the Nutrition BMP, new research emerged showing that a diversity of natural forage for bees mitigates Varroa, viral, and Nosema challenges as well as exposure to pesticides. Thus, this BMP was expanded considerably and included planting forage for bees to prolong foraging opportunities before and after crop pollination events. New research also illuminated the interaction between Varroa and Nosema, and therefore pest and disease BMPs emphasized keeping both under control. Transportation BMPs were developed to facilitate beekeepers trucking colonies to California. Collaboration with the CDFA Plant Health and Pest Prevention Branch facilitated the development of greater web presence and availability of information on the Border Protection Stations and transporting colonies to California for specialty crop pollination. The project allowed for accessing the most recent research data and translating it to real-time practical management techniques through social media and traditional platforms to provide the latest BMP information to beekeepers and growers.

Baseline measurements at the onset of the project were as follows: 1) enewsletter subscribers numbered 400, 2) available printed materials mainly included 200 copies of "A Seasonal Guide for Beekeepers Pollinating Almonds," with most other print materials out-of-date, 3) five e-learning modules accessible by web, 4) monthly BMP website hits of approximately 125 hits per month, 5) four YouTube videos, 6) seven BMP areas, and 7) no Twitter or Facebook presence.

Targets included expanding upon print materials and BMP areas, having a greater Twitter, Facebook and YouTube presence, expanding electronic newsletter presence and number of subscribers, posting more detailed BMP information on the web, developing a new BMP area, and presenting at one state, one national and one grower meeting per year.

The targets were met and surpassed. Electronic newsletter subscribers increased 400%; more than 7,000 printed BMP information sheets or brochures were distributed; journal and print article circulation exceeded

100,000; web-based outreach mechanisms which published and posted BMP materials generated approximately 60,000 views. These views included over 50,000 new views on YouTube, with 14 new videos produced. BMP website hits doubled to 250 hits per month. Twitter followers increased from zero to 142, Facebook followers from zero to 808, and YouTube subscribers from zero to 163.

The new BMP area of Transportation BMPs was developed, with a YouTube video about transporting bees to California being highlighted on CDFA's Pollinator Protection webpage.

One specific target for the grant included attending one state, one national and one grower meeting per year to promote BMPs. By the conclusion of the grant, 44 total presentations were made at four grower meetings, eleven regional meetings, nineteen state meetings and ten national meetings.

At the beginning of the project, beekeeper familiarity with social media tools such as Facebook and Twitter was minimal. Surveying beekeeper meetings found no use of Twitter and only five participants using Facebook in meetings of approximately 60 attendees. In surveys conducted in the final weeks of the project, again with approximately 60 attendees, ten participants surveyed used Twitter, with 22 using Facebook. Beekeeper familiarity with the terminology "BMPs" was at 20% at the start of the project and 70% at the completion of the project.

Results of two national honey bee health surveys, the BIP survey and the National Agricultural Statistics Service (NASS) survey were analyzed and compared to baseline data on honey bee health. Bee health has improved, when comparing baseline data for over-wintering losses at the beginning of the grant with that at the end of the grant. Over-wintering losses of 23.1% this past winter (2014-2015) were reported by BIP compared to 30.5% losses at the start of the grant (2012-2013). Total colony losses, including summer and winter losses were also down from about 45% to 42%. Honey production is up 21% since 2012, and the number of honey-producing colonies is up 5% since 2012.

The major successful outcomes of the project are numerous, and the project far exceeded expectations. Bee health has improved during the time period of this project based upon national surveys of over-wintering colonies, total colonies numbers and honey production. Beekeeper and grower focus on BMPs has increased. Beekeepers are more familiar with the terminology BMPs, and there are considerably more articles and presentations on honey bee BMPs than ever before. In traditional media outlets, this project generated 44 presentations on BMPs at four grower meetings, eleven regional meetings, and nineteen state meetings and received national attention at ten different meetings. Trade shows allowed distribution of BMP materials to over 12,000 individuals. Print media coverage of honey bee BMPs reached an audience of over a quarter million. More than 8,000 printed brochures and handouts were distributed.

Expansion to social media outlets was successful and provided quickly-accessible and frequently-updated BMPs. A well-visited BMP tab on the Project Apis m. website now serves as a clearing house of information on honey bee BMPs, with the BMP hits on the website doubling during the course of the project. Thirty monthly enewsletters highlighting seasonal BMPs were published with the subscriber base quadrupling during the course of the grant. Fourteen YouTube videos were produced, with total views on BMP videos exceeding 50,000 views. Two individual YouTube videos were extremely popular; views of the Varroa BMP video doubled, while views of the Transportation BMP video increased by over 70-fold. Facebook "Likes," Twitter followers and YouTube subscribers grew from being nonexistent at the beginning of the grant to an increase of 808, 142, and 163, respectively.

Beneficiaries

Beneficiaries of this project's numerous accomplishments include California's specialty crop producers who rely on bees to pollinate their fruit, nut, vegetable, herb, spice and seed crops and the commercial beekeepers who manage the honey bee colonies needed to pollinate California's specialty crop industry.

Growers benefit from honey bee BMPs because the BMPs help to ensure a more sustainable supply of honey bees. Having adequate numbers of strong, healthy honey bee colonies for California's specialty crops is a challenge, and seasonally-appropriate, continually-updated, and frequently-presented honey bee BMPs help beekeepers and growers.

The number of beneficiaries of this project includes California's specialty crop producers who rely on bees to pollinate their fruit, nut, vegetable, herb, spice and seed crops. These producers represent nearly 50 different crops with a farm gate value of approximately $8 billion. The over 1,000 commercial beekeepers who manage the 1.7 million colonies needed to pollinate California's specialty crop industry are also beneficiaries of this project's accomplishments. And, in particular, California's 6,000+ almond growers, who are 100% reliant upon honey bees to set their crops, directly benefit from greater outreach and information on honey bee BMPs.

Nationwide, the direct and indirect contribution of honey bees, farm to income, is substantial; estimated at $20 billion.

Lessons Learned

The two most effective means of outreach for BMPs to beekeepers and for growers renting bees for pollination of their crops are still more traditional methods, including: 1) presence at beekeeper and grower meetings to promote BMPs and to demonstrate how to access BMPs on the web, and 2) print articles in local newspapers and agricultural and bee journals. For these traditional methods, it is recommended that provocative presentation titles and article titles be employed to draw attention to the BMP message. Visual means should be fully utilized. Good quality, colorful photographs are important in drawing attention to the material. PowerPoint presentations must maximize visual interest and minimize the reading of words in order to captivate an audience.

Similarly, enewsletters can easily reach the targeting audience. However, in order for enewsletters to achieve a high open rate, as was accomplished in this project, the subject line of the enewsletter must irresistibly entice the reader to open the enewsletter. Once opened, a colorful lay-out, comfortable design, and descriptive, relevant photographs keep readers reading the enewsletter. Good programs exist to manage enewsletter content and subscriber lists, and the better programs provide more data on readership. "Click-through" rates (where a reader goes to an inviting link provided in the enewsletter) can be an additional measure of engagement by enewsletter. Monthly enewsletters are about the right frequency; too many enewsletters will result in individuals unsubscribing, and too few enewsletters will result in information not being anticipated.

The web provides an unparalleled opportunity to maintain up-to-date information on honey bee BMPs. However, in-person presentations, trade show booths and enewsletters are also required to inform the target audience that web pages containing useful information are available.

To access those not reached via live presentations or who are unaware of the webpage opportunity, Facebook is a social media vehicle to encourage engagement and website visits. The advantage of Facebook postings is that they can be brief and to the point. Visuals are important. However, Facebook postings are most effective when posted frequently (once a week) to keep engagement active.

YouTube videos with a strong relevant message and interesting high quality videography are an increasingly popular method of learning. Greater commitment to YouTube learning opportunities should be pursued by beekeeper and grower communities.

Finally, BMPs need continual evolution as novel research is published, new pests and pathogens are discovered, and more insight is gained about the relationship between honey bee challenges and honey bee management practices. There continues to be much to learn about honey bee health and honey bee stressors. As new information is uncovered, the information needs to be translated into better management techniques and new BMPs. The numerous requests for BMP presentations at times exceeded the staff's ability to meet the demand.

The Honey Bee BMPs are a frequently requested topic at beekeeper and grower meetings. New Varroa research is being undertaken so as to control this pest before it reaches its 30th anniversary in this country. The new research will result in new Varroa control measures and new Varroa BMPs. More information about honey bees' nutritional needs and the microbiome of the honey bee gut is becoming available, with practical value relating to honey bee foraging and longevity. Grower BMPs is a necessary area of expansion. New research on the impact of pesticides on the various life stages of the honey bee has a direct effect on grower pesticide application practices, and it is vital that outreach be conducted in this area.

Implementing this project resulted in cooperative relationships with BIP, the Almond Board, and the California Association of Pest Control Advisors (CAPCA), such that the target audience for honey bee BMPs and outreach was greatly expanded. Both BIP and the Almond Board also created complementary BMP efforts that expanded information dissemination and outreach opportunities. Overall visibility of this project exceeded expectations.

Additional Information

Please see List of BMP presentations Attachment A.

The BMP website tab can be found at: http://projectapism.org/?page_id=342
Enewsletters can be found at: http://projectapism.org/?page_id=390
On YouTube, type in "Project Apis" in YouTube's search bar. www.YouTube.com

Other resources:
www.facebook.com/projectapis
www.twitter.com/projectapis

USDA Project No.: 10	Project Title: Expanding Specialty Crop programs for students in the Sierra Nevada Regions	
Grant Recipient: El Dorado County Ag in the Classroom	**Grant Agreement No.:** SCB 12010	**Date Submitted:** December, 2015
Recipient Contact: Avis Jolly	**Telephone:** 530-303-8117	**Email:** a.jolly@agintheclass-edc.org

Project Summary

The El Dorado County total gross crop value was $35 million in 2010 and specialty crop values were $21.3 million. According to the United States Department of Agriculture 2012 Census of Agriculture, 79% of the 1,358 farms in El Dorado County are smaller than fifty acres, and most of these farms are California specialty crop producers. The competitiveness and viability of these small rural farms relies on informed consumers and decision-makers in the community. It is vital that students, educators, and the public understand the positive contributions that local specialty crop producers make to the health of people, health of the economy, and health of the natural environment. The heightened awareness and appreciation for specialty crops resulting from this project's activities will help local specialty crop producers remain competitive. All local specialty crop producers in El Dorado County are the ultimate beneficiaries of project activities. To increase outreach to socioeconomically disadvantaged students, El Dorado County Agriculture in the Classroom piloted Tahoe Farm Day, introduced students to the importance of specialty crops and the concepts of healthy food choices, and provided "Ag Day" field trips for children and mentors in the local Big Sisters and Big Brothers program.

By providing agriculture-based education through school/farm partnerships, training teachers, and reaching socioeconomic disadvantaged children, the impacts are immediate and long-term. This heightened awareness will help local specialty farms remain viable.

This project builds on a previously funded Specialty Crop Block Grant Program project. The 2008 Specialty Crop Block Grant Program funded two specialty crop education pilot projects: Field of Learning (FOL) school/farm partnership program, and the Teacher's Agricultural Summer Institute (TASI). Building on the success of the earlier pilot projects and employing lessons learned in the process, this project strengthened these education programs, significantly increasing the number of students and teachers who learned about specialty crops. Initiating six new FOL partnerships based on the initial pilot program provided an opportunity to expand the number of students reached, geographically and in grade level. Training Agriculture Leadership students as FOL field coordinators increased the effectiveness of the FOL program while educating high school students about local specialty crops. Providing orientations for new school/farm partners provided a strong foundation for the long-term success of the program. Initiating three day-long Teacher Ag Workshops increased teacher accessibility to the program as well as the specialty crop curriculum highlighting local production, benefits, and value.

Project Approach

During the South Lake Tahoe (SLT) Farm Day 2013, the following tasks were performed: Surveyed teachers, developed educational activities, recruited presenters, provided teacher training, conducted event, evaluated results of pre and post testing of students, and teachers' and presenters' evaluations. The goals for this project were adjusted in accordance with the 2013 evaluation findings which showed that it improved specialty crop learning activities, and allowed for the development of pre-and post-testing process which was utilized at SLT

Farm Day held on September 16, 2014. Two specialty crop learning activities were developed and each activity was provided at three learning stations each, reaching each of the 540 and plus, third and fourth grade students who attended. Pre and post tests were administered in the students' classroom prior to and after SLT Farm Day. The key performance measure for SLT Farm Day 2014 was whether participants could identify regionally grown specialty crops. Testing showed a significant increase in knowledge: Pre-test: 30% correct; post-test 81% correct. These revised project goals allowed for significant improvements from the initial 2013 SLT Farm Day, where only an 18% increase in specialty crop identification occurred, from pre to post assessment. In both 2013 and 2014 SLT Farm Days, a significant percentage of participating students were socio-economically disadvantaged and English-learning students.

The fall and winter farm visits for Fields of Learning (FOL) grew from 2013 through 2015, to ultimately include six school/farm partnerships, thus meeting target goals. The FOL farm Days were conducted at local farms: 1. El Dorado Hills Natural Farms partnered with Blue Oak Elementary second grade, 2. Smokey Ridge Ranch partnered with Green Valley Elementary third grade, 3. Gold Bud Farm partnered with Gold Oak Elementary first grade, 4. Holly's Hill Vineyards partnered with Gold Oak Elementary fifth grade, 5. Rainbow Orchards partnered with Golden Hills School first and second grade, and 6. Madroña Vineyards partnered with Louisiana Schnell Elementary fourth grade.

Although the FFA student recruitment of six students for the 2013/2014 school year was less than anticipated, the recruitment information session, application, and orientation process implemented for 2014/2015 school year yielded fifteen student leaders, meeting the target goal of twenty over the two year period. Over the two school year period, significant steps were taken to improve the program and specialty crop knowledge. Two assessments were administered during the 2013 to 2014 FOL academic year. These assessments not only included the identification of specialty crops, but also included environmental, earth, and biological concepts as they relate to specialty crops. It was determined that different assessments were required as the participating grades in the FOL school ranged from Kinder to fifth grade. During the 2014/2015 school year students' knowledge about specialty crops increased such that an average 76% of students scored passing grades on the assessment, which measured specialty crop knowledge by year end. Given there was no benchmark data in advance, this 76% against the goal of 80% is considered extremely positive, especially as the assessments developed were much more than simply the "identification of specialty crops." During the 2014/2015 FOL academic year, more care has been taken in reviewing assessment results and making modifications to teachings to ensure lower scoring subject matter was addressed during subsequent visits. This resulted in a positive change. Eight-five percent of the students who did not receive a passing grade at the year start, by year end, this was decreased to only 9%; well above the 20% target.

Project goals were revised to include three, one-day specialty crop workshops called Teacher Ag Workshops, which were held on November 21, 2014, February 11, 2015, and March 26, 2015; and included visits to nine local farms: Smokey Ridge Ranch, Rainbow Orchards, Crystal Creek Tree Farm, Wakamatsu Silk & Tea Colony, Mad Dog Mesa, Hooverville Orchards, Bluebird Haven Iris Garden, Fausel Ranch, and Holly's Hill Vineyards. In addition, farmer guest speakers with expertise in entomology/pest management, dormancy/bare root planting/pruning, and bees/apiary provided the attendees additional education related to specialty crops. Attendees received resources and lesson plans that supported workshop learnings and were ready to be implemented in the classroom. Pre and post tests were administered for a total of twenty-nine attendees who scored 70% knowledge gain for the final workshop. However, a 70% knowledge gain would have required a 100% score on the final assessment by all attendees, so these results were still considered a success.

Two, one-day Ag Days for Big Brothers Big Sisters (BBBS) were planned and delivered, including developing educational activities; recruiting specialty crop producer hosts; signing up mentors and children, recruiting volunteers, developing pre and post assessments, and participant evaluations. The events were held in September 2014 and April 2015 at Rainbow Orchards, in El Dorado County. In the fall, twenty-six adults and children were signed up to attend, but five matches cancelled due to conflicts. Attendance totaled eight "matches" (seventeen adults and children). In scheduling the spring “Ag Day” for BBBS, prior scheduling issues were taken into consideration and over twenty-four adults and children were in attendance. Pre and post tests were given to adults and children attending, and results showed significant increase in knowledge of the specialty crops. In both occurrences, zero of the child participants scored 100% on the pre-test, and only a one to two adults; and in both occurrences, all participants received passing grades on the post-test, with the majority scoring 90% or higher.

Six specialty crop Virtual Field Trip (SCVFT) Videos were produced along with corresponding learning activities. The production required coordination of pre-production works including work plans, script development (specialty crop educational content), and logistics as well as filming, post production, and pilot presentations. These videos covered the following subject matter and/or their relationships to El Dorado County’s specialty crop and their production: 1) El Dorado County Ag in the Classroom & specialty crops 2) Apples 3) Bees & Blossoms 4) Water 5) Simple Machines and 5) Dormancy. These videos were shot in the spring and final editing completed late in the 2014/2015 school year. These videos and corresponding lessons were released via the El Dorado County Ag in the Classroom website www.agintheclass-edc.org, meeting the accomplishment of reaching all school systems geographically dispersed in the county’s 1750 square miles divided by the Sierra Mountain range, whose foothills are the bulk of the specialty crop growing region resides. This allowed access to this educational element, despite the system’s socio-economic diversity, reaching from the more financially-infused western slope that borders on the state’s capital with abundant businesses and higher household incomes, to the underserved eastern slope whose students are more disadvantaged.

Project costs were monitored to ensure Specialty Crop Block Grant Program funds were used solely to enhance the competitiveness of California specialty crops.

The Lake Tahoe Unified School District and their Science Outreach Coordinator contributed greatly in the development of specialty crop learning activities for South Lake Tahoe Farm Day and the administration of the pre and post testing of students participating in SLT Farm Day. Ponderosa High School Future Farmers of America (FFA) teachers/advisors played an important role providing coordination, encouragement, and leadership in working with FFA Student Field Coordinators for Fields of Learning. Big Brothers Big Sisters of El Dorado County were enthusiastic partners in planning and implementing an effective “Ag Day” (Day at the Farm) for the mentors and children in its program.

Goals and Outcomes Achieved

Performance monitoring put into place were all short-term assessment-types with the exception of the specialty crop Virtual Field Trip (SCVFT) Video Series, which has yet to be released broad-scale; however, the group of persons who served on the pilot presentation review committee, consisting of El Dorado County Office of Education, local school administration and agriculture educators, as well as El Dorado County University of California Cooperative Extension Natural Resources personnel, provided incredibly positive feedback to the potential of this part of the project.

South Lake Tahoe (SLT) Farm Day is a new and unique program with no existing benchmark. South Lake Tahoe's location and socio-economically disadvantaged demographic disables the student population from readily receiving access to the county's major specialty crop growing region as well as AITC's programs. SLT Farm Day implementation was instrumental in creating locally accessible avenue for SLT students to learn about the county's specialty crops and their importance to health, economy, and the natural environment. The key performance measure for SLT Farm Day 2014 was whether participants, 400-500 third and fourth grade students, could identify regionally grown specialty crops. Testing showed a significant increase in knowledge: Pre-test: 30% correct; post-test 81% correct. This exceeded the target of 50% improvement in post-test results over pre-test results. The adjusted goals allowed for significant improvements from the initial 2013 SLT Farm, where only an 18% increase in specialty crop identification occurred from pre to post assessment.

This "in the field" experiential learning opportunity allowed local students the opportunity, through hands-on education, to learn about local specialty crops and their role in health, environment, and economy directly from the producer. In addition to the pure academic aspect, long term, this will create a child who will become a more vested adult with a heightened awareness of their community that will help local specialty farms remain viable. Two assessments were administered during the 2013/2014 FOL academic year. These assessments, not only included the identification of specialty crops, but also environmental, earth, and biological concepts as they relate to specialty crops. It was determined that different assessments were required as the grades in FOL school participants ranged from kinder to fifth. Results of data:

	13-14 Start % Score >60%	13-14 End % Score >60%	14-15 Start % Score >60%	14-15 End % Score >60%
24 pt	40%	18%	100%	0%
25 pt	80%	30%	70%	18%
Average	60%	24%	85%	9%

During the 2014/2015 FOL academic year, more care was taken in reviewing assessment results and making modifications to teachings to ensure lower scoring subject matter was addressed during subsequent visits. In addition, learning was enhanced with the implementation of the learning kit components. By the end of the 2014/2015 academic year, the target goal of 80% passing was exceeded with 91% passing scores.

The Teacher Ag Workshops had a benchmark of 53% increase in knowledge, based on 2011 assessment inaugural TASI teacher pre-post assessments. Three mostly unique pre and post assessments were developed and delivered to correspond to the unique nature and specialty crops covered during the three different workshops. Results of data:

	Pre	Post
November 2014	34%	90%*
February 2015	30%	80%
March 2015	30%	98%

The November workshop had eleven attendees assessed for the pre assessment; however, two attendees required an early departure and therefore the post sample could have showed a higher percentage had they been part of the sample. The February, 2015 workshop was severely impacted due to one particular school district failing to secure subs the morning of the event and preventing three registered teachers from attending, so the sample size and attendees were only seven. The March workshop was well attended with eleven and with many new to the programs a lot of learning occurred and was noted in the 68% specialty crop knowledge rise from pre to post. Note this final assessment was only 2% shy of target of 70%, but a 70% increase would have required 100% scores on the assessments. Also, it is important to note that the attendance goal initially was twenty four to thirty six teachers, and with twenty nine, this was goal was attained.

The Ag Days for Big Brothers Big Sisters (BBBS) was a new and unique program so no benchmark data exists. Results of the pre and post tests showed significant increase in knowledge of specialty crops. In both occurrences, all participants received passing grades on the post-test with the majority scoring 90% or higher.

The specialty crop educational reach of the programs provided by El Dorado County Ag in the Classroom via this project increased the reach not only in quantifiable numbers, but also in geographic and socio-economic areas of the county that were previously untouched, as well as expanded the base from only third grade to first through fifth grades.

Pre-Project
Placerville Farm Day = 600 students

Post-Project (as of June 30, 2015)
Placerville Farm Day = 1,200 + students
South Lake Tahoe Farm Day = 600 students
Field of Learning = 500 students

~ 2,300 + County Youth + More via Ag Workshops, BBBS, & SCVFT Video R

3rd Grade → 1st through 5th Grade Represented
Teachers, Presenters, Students → Teachers, Presenters, Students, Farmers, and FFA
Western Slope → El Dorado Hills to South Lake Tahoe and beyond as requests to share the project are received from the Mother Lode area.

Beneficiaries

All local specialty crop producers in El Dorado County are the beneficiaries of this project.

FOL - Local public and private elementary schools: Blue Oak Elementary second grade, Green Valley Elementary third grade, Gold Oak Elementary first grade, Gold Oak Elementary fifth grade, Golden Hills School first and second grades, Louisiana Schnell Elementary fourth grade.

South Lake Tahoe (SLT) Farm Day: South Lake Tahoe Unified School District and all elementary school entities within their jurisdiction.

Teacher Ag Workshops: Elementary teachers from El Dorado County elementary and middle schools, public, private, and charter including Camino Elementary, Blue Oak Elementary, Golden Hills School, Markham Middle School, American River Charter, and Rescue Elementary School.

Ag Days for Big Brothers Big Sisters (BBBS): Big Brothers and Big Sisters of El Dorado County Mentors, Mentees, and Staff

Specialty Crop Virtual Field Trip (SCVFT) Video Series: Yet to be realized, but the videos will be released through the El Dorado County Office of Education as well as other communications in hopes to reach all elementary education institutions within the county.

Fields of Learning (FOL): Approximately 300 elementary school students and indirectly their corresponding teachers and chaperons.

South Lake Tahoe (SLT) Farm Day: Approximately 500 third and fourth grade students and indirectly their corresponding teachers and chaperons.

Teacher Ag Workshops: Twenty-nine elementary teachers and indirectly their students

Ag Days for Big Brothers Big Sisters (BBBS): Forty-one Big Brother-Big Sister matches and indirectly the BBBS staff in attendance.

Specialty Crop Virtual Field Trip (SCVFT) Video Series: Yet to be realized, but realistically hundreds of El Dorado County elementary educators and thousands of El Dorado County elementary students and potentially beyond the county boundaries.

El Dorado county farms: 1,358 small farms growing 79% of specialty crops.

El Dorado Hills Natural Farms, Smokey Ridge Ranch, Gold Bud Farm, Holly’s Hill Vineyards, Rainbow Orchards, Crystal Creek Tree Farm, Wakamatsu Silk & Tea Colony, Mad Dog Mesa, Hooverville Orchards, Bluebird Haven Iris Garden, Fausel Ranch, and Madrona Vineyards.

Lessons Learned

There has been substantial growth and interest in the programs. More schools and educators want to engage than this organizations capacity planning model will currently allow. Currently, all programs are currently being held flat for the 2015/2016 school year while the Steering Committee and Board of Directors evaluate program viability and implement organizational capacity building steps for growth.

There were some staffing issues in the beginning of the project period. When the application process for the grant project was in process, contractual services should already have been in the investigative stages to ensure the proper staffing is in place from the start of the project.

Again, the sheer growth and interest was a major unexpected outcome. The project staff are receiving requests from others, most notably the Mother Lode Farm to School Network, to share this project’s best known methods (BKMs) for others to draw from. Nevada County is currently implementing a Farm Day based on this existing Placerville Farm Day and the SCBG-developed South Lake Tahoe Farm Day. Calaveras County is currently looking to reproduce this Fields of Learning model as a pilot farm this fall.

Outcome measures were achieved in all areas except the Teacher’s Ag Workshop which fell short by 2 percentage points to the goal of 70% knowledge improvement. However, not taken into account was that the teachers who attended the workshop already had an interest in the subject matter with some participating in other programs, and therefore were not coming with a “zero” knowledge base. Therefore 70% growth was almost unattainable when a 30% score on the pre-assessments was the baseline, as it would have required 100% scores on the post-assessments.

Additional Information

El Dorado County Ag in the Classroom homepage www.agintheclass-edc.org

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.:	Project Title:	
11	Digging In: Guiding Farm Success through In-Depth Business and Land Tenure Education	
Grant Recipient: California FarmLink	**Grant Agreement No.:** SCB12011	**Date Submitted:** December 2014
Recipient Contact: Reggie Knox	**Telephone:** (831) 425-0303	**Email:** Reggie@cafarmlink.org

Project Summary

This project sought to address and provide assistance to overcome the obstacles faced by beginning specialty-crop growers in California to access and manage land and capital needed to launch and build successful businesses. A 2011 survey of 1,000 beginning farmers by the National Young Farmers Coalition identified lack of capital (78%) and land access (68%) as the two biggest challenges faced by beginning farmers. A 2011 California study of Latino specialty crop growers showed "Business Planning/Finance" as the top assistance priority. Often due to lack of business management acumen, California farms with less than 5 years in business have a 40% failure rate. The project sought to address these key challenges: difficulty in finding land, negotiating solid tenure agreements, and accessing financing to start or expand businesses; and cultural or language barriers.

California FarmLink's 2008 Specialty Crop Block Grant Program project "Specialty Marketing Technical Assistance for Beginning Farmers and Farms in Transition" achieved significant long-term successes in providing specialty crop growers with land tenure, business planning, and marketing training, supporting the core project focus of keeping family specialty-crop operations in business through farm succession planning trainings and assistance. FarmLink provided tools and resources on key legal, tax and family communication issues in farm succession to 85 specialty crop farm families, covering 100,000 acres and multiple generations. More than 60% of these families reported making significant progress towards implementing succession plans in this first systematic statewide effort to provide California specialty crop growers with affordable succession planning support. Through that project California FarmLink became the leading group in the state assisting specialty crop growers with succession issues, and went on to 1) train other groups in providing farm succession training, and 2) leverage additional resources to continue specialty crop succession training in subsequent years, training hundreds of additional farm families in succession planning.

The 2008 project also enabled California FarmLink to develop a strong marketing assistance training module for specialty crop growers, which the organization continues to use and expand, assisting growers to develop profitable marketing strategies well-suited to the type and scale of operation.

The core focus of this current project built on the marketing education component through 1) development of individualized, specialized consultants who are able to support specialty-crop growers in growing their business and market reach, and 2) a strong emphasis on access to financing to encourage farm financial sustainability, and increase farm sales, gross income, and job creation among small and low-resource specialty crop producers.

Project Approach

The activities completed included: planning (at least) four workshops in each region; conducting a needs assessments for the 61 individual farmer participants; administering and advertising workshop evaluations; presenting at fourteen workshops and two mixers; and holding extensive one-on-one advisory and technical assistance (TA) sessions with specialty crop growers in the three regions. The activities completed are discussed in detail below:

- Hold planning meetings with collaborators in each region for educational events (skills building sessions/workshops) and grower outreach activities.
  - California FarmLink regional coordinators held planning meetings with collaborators for each regional educational event and created specialized events based on collaborators' and the needs of local specialty-crop growers.
- Update FarmLink's "Business Plan Workbook for New Farmers" and publish for use in workshops.
  - This work was completed in July 2014.
  - The Business Plan Workbook was provided to and used only for technical assistance for specialty crop growers participating in this project.
- Develop, administer and synthesize evaluations of project educational and advisory activities.
  - Evaluations for this project were developed at the outset, administered throughout, and synthesized regularly. Final evaluations for the project have been synthesized for this report.
- Review/update FarmLink educational materials; prepare written materials and educational modules for workshops; make available on website.
  - The following FarmLink educational resources were provided at the events for this project and are also posted on the California FarmLink website (www.cafarmlink.org): *Farm Financing Sources; Financial Literacy; Financing Your Farm; Why Borrow Money for Your Farm?; Cash Flow Fact Sheet;* and *Cash Flow Tips for the Cash Flow Spreadsheets (includes Excel spreadsheets for use): Year; Income; Expenses*; *Small Farm Tax Organizer*.
- Establish 50 growers in growers' groups (over 3 regions) for one-on-one and small group sessions with advisory groups and consultants from workshops and collaborator recommendations.
  - FarmLink worked with 61 growers individually, after determining that small group sessions were not the most effective way to serve the growers. These individualized sessions featured in-depth assistance from FarmLink professionals, as well as marketing, accounting, bookkeeping, and social media experts.
- Evaluate specialty-crop grower participants' farm business needs and collect baseline business knowledge and farm economic data.
  - FarmLink collected baseline business knowledge and farm economic data. Participants' needs were evaluated through a self-assessment of knowledge or experience in 14 key financial, business, marketing, and lease topics, as well as a questionnaire that asked about which aspects of the program would be most useful. Data to evaluate needs and progress was also gathered on numbers of acres being farmed, number of employees, farm enterprise types, marketing strategies, and sales and profit.

- Organize one-on-one consultant technical assistance sessions.
  - Every participating specialty-crop grower in this project received individual technical assistance from California FarmLink and/or one of the two designated partners, Kitchen Table Advisors (KTA) and Sustainable Economics Legal Center (SELC). Twenty-four also received individual assistance from external professional consultants on topics ranging from social media marketing and marketing strategies for their particular crops to enterprise analysis and bookkeeping strategies for success.
- Develop advisory group for each region; regional/local organizations help identify qualified candidates.
  - FarmLink developed a group of advisors for each region to work with the local specialty-crop growers. FarmLink completed a needs assessment for each participating farmer to maximize their time with consultants. The assessments led to the decision to match growers individually with professionals to address their specific needs.
- Conduct outreach to landowners in each region to develop lease/partnership/succession opportunities for growers.
  - Regional coordinators developed a focused outreach effort to landowners in each region at least once each year of this project, in addition to developing stronger support resources for all landowners.
- Evaluate participants' change in knowledge and business success for the duration of this project.
  - All participants responding to exit evaluations reported increases in knowledge or experience in topics that included financial goal-setting; cash-flow management; business planning; record keeping; assessing financing needs; assessing profitability of sales outlets; marketing planning; and leases/land tenure. Twenty-two reported an increase in gross sales; eight reported adding jobs, for a total of sixteen jobs.
- Compile and communicate project findings with other organizations, agencies, and growers.
  - FarmLink shared project findings and the numerous resources that were developed through the networks of specialty-crop growers and partner organizations that support farmers, at the events, and in consultation with individual specialty-crop growers, as well as on the website and in the newsletter, as appropriate.
- Publicize and hold at least four workshops and educational opportunities, including a landowner-beginning farmer "mixer" (to facilitate potential land tenure agreements) in three regions.

Region 1 (Central Coast) Workshops/Events:

1. January 24, 2013. "Business Planning Bootcamp for New Farmers" workshop at the Ecological Farming Association (Eco-Farm) Annual in Pacific Grove, California. 105 attendees. All participants found the workshop to be useful; 74 percent gave ratings of "very useful" or "useful". Seventy-five percent said that knowledge of the topic was increased.
   - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.
2. January 24, 2014: "Credit 101 and Business Borrowing" workshop at the EcoFarm Conference. Provided finance and credit information and helped specialty crop farmers understand how to prepare for borrowing and how lenders use credit history to make lending

decisions. 26 attendees. Nine participants returned evaluations, and gave a rating of "useful" or "very useful." Five said knowledge of the topic was increased "very much"; three reported "somewhat" of an increase. One attendee commented that the session was very informative, and expressed appreciation for the presentation.

- Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.

3. February 24, 2014: Farm Finance Expo in Aromas. 33 attendees. Participant feedback was especially positive about the lender panel (*Operating, Equipment, Infrastructure and Farm Purchasing Loans; Micro & Social Network Based Lending, Crowd-funding; Keys to Successful Loan Applications*), which included an engaging question and answer session. In addition to the lender panel, participants most liked learning about finance and lenders, and the workshop format. Comment: "Fantastic intro to many lenders in one afternoon."
   - Funded 90% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 90% of the attendees were specialty crop growers. Only 90% of the costs were charged to SCBGP.
4. October 26, 2013: Small Farm Financing Workshop at the San Luis Obispo Bioneers Conference. Discussed was an overview of the different lenders that work with small farmer, information about non-conventional funding sources, the steps to financing, and FarmLink's lending program. Farm Credit West spoke about their loan program and what lenders look for in a loan application. Slow Money also provided information about their opportunities.
   - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.
5. January 24, 2014: "Slow Money/Financing Your Farm" workshop at the Ecological Farming Association (EcoFarm) Annual Conference. Workshop focused on financing options for farmers, including local non-profit institutions that provide assistance to farmers. FarmLink provided information on collaborative lending (i.e. working with borrowers who are accessing capital from multiple sources) and eligibility criteria for FarmLink's loan program. A specialty crop farmer presented about experiences working with both FarmLink and Slow Money Northern California to obtain financing. Speakers shared experiences working with other alternative lenders, from government programs to online sources of crowdfunding.
   - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.
6. January 23, 2014: Landowner/Farmer Mixer at the EcoFarm Annual Conference. 160 attendees. Connections included: help selling/distributing farm products; meeting small, beginning farmers; collaboration between local farmers; business model networking; connecting with California FarmLink; internship opportunities; and learning about potential land opportunities.
   - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.
7. March 19, 2014: Lease and Marketing Clinic at Springfield Grange near Watsonville.

27 attendees. Many participants were students of the Agricultural Land-Based Training Association (ALBA)'s Programa Educativo para Agricultores (PEPA)--Farmer Education Program. One workshop activity enabled attendees to apply what was learned in the workshop to their own unique situations; this was a highlight for most participants.

- Funded 90% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 90% of the attendees were specialty crop growers. Only 90% of the costs were charged to SCBGP.

Region 2 (Central Valley) Workshops/Events:

1. December 12, 2013: Farm Finance Expo in Sacramento. 35 attendees.
   Participant feedback especially positive about the farmer panel; participants also liked networking with farmers and lenders and the opportunity to obtain financing information. Thirteen respondents plan to apply for a loan in the next 1-3 seasons; all reported that the Expo will be helpful.
   - Funded 90% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 90% of the attendees were specialty crop growers. Only 90% of the costs were charged to SCBGP.
2. January 19, 2014: "Financing Your Small Farm" at the Nevada County Sustainable Food and Farm Conference Workshop. Presentations focused on flexibly-structured financing for farmers who would otherwise have a difficult time securing financing due to barriers. 35 attendees, and 23 evaluations were returned; 20 rated the presentation as "useful" or "very useful"; and 3 as "somewhat useful." 15 said their knowledge of the topic was increased "very much," 8 said their knowledge increased "somewhat."
   - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.
3. July 12, 2014. "Farmers and Landowners" at the Center for Land-Based Learning in Winters, California. Mixer provided opportunities for farmers and landowners to connect. 40 attendees. Evaluations completed by 33; 25 reported making useful connections. On a scale of 1 – 5 (with 1 as lowest and 5 as highest), the event rated 4.4. The event was described as "great" by a consensus of attendees. Several would have liked to have met more landowners. (FarmLink is always working to identify landowners and increase land opportunities.) Suggestions also for more structure for introductions, and a system to identify participants' interests and offerings. These suggestions will be incorporated into future events.
   - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.

Region 3 (North Coast) Workshops and Events:

1. October 17, 2013: Farmer-Landowner-Local Advocates Mixer in Sebastopol, California. FarmLink partnered with the Community Alliance with Family Farmers (CAFF) to host the mixer. 110 attendees; FarmLink facilitated "mixing" to introduce farmers and landowners for lease/partnership/succession opportunities for specialty crop growers.

- Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.

2. February 13, 2014: Farm Finance Expo in Santa Rosa, California.
Participants included: Umpqua Bank, Safe-Bidco, Slow Money, Bank of the West, FSA, Sonoma County SBDC, U.S. Small Business Administration (SBA), Tierra Vegetables, Quarter Acre Farm, and Victorian Farmstead. 23 attendees. Farmers appreciated the lender panel; talking with lenders; farmer panel, interacting with a diverse group of lenders; networking; and question and answer panels. 9 plan to apply for a loan in the next 1-3 seasons and said that Expo will help. Participants will use ideas from Expo to: begin and improve business planning; apply for a loan; focus on the "5 Cs" of credit; research crowd sourcing; lease property; and secure financial records for future loan applications.
    - Funded 90% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 90% of the attendees were specialty crop growers. Only 90% of the costs were charged to SCBGP.
3. March 11, 2014. "Microloan Options for Small Farms" at the California Small Farm Conference in Rohnert Park, California. Organized by California Small Farm Conference. Session focused on microloans and short-term loans from $500 to $15,000. Speakers covered the process and requirements for loan application and approval, and an overview of financing options small-scale producers. 10 specialty-crop growers attended; more than half saying that their knowledge of the topics was increased very much.
    - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.
4. March 5, 2014. North Coast Farmers' Convergence. 250 attendees; good opportunities for education, networking, and information sharing. Organized by North Coast Opportunities; FarmLink collaborated in planning and promotion. FarmLink provided information to more than 50 specialty crop growers; met one-on-one with 10; also connected with landowners and retired farmers to discuss land listings, and ways to stimulate more interest from farmers.
    - Funded 50% by FarmLink with SCBGP funds. FarmLink had sign-in sheets and confirmed that more than 50% of the attendees were specialty crop growers. Only 50% of the costs were charged to SCBGP.

<u>All Regions</u>:

1. March 27, 31 and April 1, 2014. Introduction to Income Taxes for Small Farms; Webinars. Presentation and workbook, the *<u>Small Farm Tax Organizer</u>*, were developed for the specialty crop grower participants by the small farm business advisor who was a consultant for this project. The webinar and workbook were provided solely to the specialty-crop farmers in this project, who planned to utilize these valuable tools and resources prior to doing their 2014 taxes. The webinar, "<u>Introduction to Income Taxes for Small Farms</u>," introduced the structure of an individual income tax return for a self-employed farmer and focused on techniques for assembling the records required to prepare and support a tax return in compliance with state and federal requirements. Presentation instructed farmers on the use of the workbook, which accomplishes three purposes: 1) educate the farmer regarding the types of records to keep; 2) educate a tax preparer regarding tax issues unique

to agriculture and associated specialized resources; 3) assist a farmer who chooses to use tax preparation software for small business owners by pointing out the areas of taxation unique to agriculture, and instructing the user to find the appropriate input screens to ensure the software has the correct information to calculate a tax return for an agricultural enterprise.

Overview of project partners work with FarmLink participants:

- Sustainable Economies Law Center (SELC)
  In order to reach more Southeast Asian and Spanish-speaking farmers, FarmLink collaborated with Sustainable Economies Legal Center, who is assisting a group of Spanish-speaking specialty-crop growers in Sonoma County to formalize their business structure. Creating the legal business structure has been one of the group's main hurdles to success. This group wanted to develop a cooperative business and also was interested in creating a 501(c)3 business. SELC created many resources for this group and led meetings and trainings to help growers choose the appropriate direction for their business. SELC provided technical assistance and legal services to three Chinese immigrant specialty-crop farmers to help these growers comply with labor law. SELC's technical assistance has been critical to the success of these farm businesses.
- Resources Provided to Farmers
  - Legal handbooks, two in Spanish and two in English, all co-published by SELC:
    - El Proceso Legal Para Iniciar Tu Negocio Cooperativa
    - Creación de Granjas Comunitarias Sin Fines de Lucro
    - Think Outside the Boss: How to Create a Worker Owned Business
    - Legal Eats: Legal Resources for Food Justice Enterprise
  - Sample English/Spanish Operating Agreement for a small worker collective business.
  - Guide for the Chinese migrant farmers on preparing wage statements and timesheets. The guide has been made available to California Department of Industrial Relations (DIR), Division of Labor Standards Enforcement (DLSE) for upload to the DLSE website to fill the gap in guidance and information for employers seeking to comply with the law.
- Kitchen Table Advisors (KTA)
  Kitchen Table Advisors met regularly with eight specialty crop growers to provide one-on-one in-depth technical assistance (TA) to increase the economic viability of their farm businesses. TA included in-depth financial management support to help growers refine recordkeeping systems to better track income (by crop and by customer) and expenses; long-term business planning support to help farmers get on a path towards purchasing land and gaining long-term land tenure; and helping farmers transition from a partnership to a farm run by one sole operator.
- Poppy Davis, Small Farm Business Advisor
  This advisor, one of the farm business specialists in the Advisory groups stated under the Contractual cost category of the budget narrative for this project, developed the webinar, *Introduction to Income Taxes for Small Farms,* as well as a *Small Farm Tax Organizer* workbook, and conducted webinar events for specialty crop growers. These tools helped specialty crop growers understand how to prepare taxes and/or organize business paperwork to bring to a tax professional.

- Keith Abeles, farmer and farm marketing consultant

This consultant administered a needs assessment of all the individual farms included in FarmLink's individual assistance program to specialty crop growers through this project. The consultant directly provided marketing coaching solely to project participants needing support in that area to enhance the specialty crop growers' competitiveness; helped to expand and refine Farm Link's consultant network to provide assistance to specialty crop growers; and connected specialty crop growers with appropriate consultants.

Goals and Outcomes Achieved

Measurable Outcomes:

- 50 specialty crop growers increase their knowledge of land tenure, farm leases, farm financial management and financing, and business and marketing planning.
    - 45 of the 61 specialty crop growers who received assistance completed a follow-up evaluation. Each member of this group reported increase in knowledge in 1 to 14 different topics related to land tenure, leases, financial management, business, and marketing planning.
    - Here is a success story shared by a participant about the individualized Quickbooks training received from a project advisor:
        - "I wanted to personally thank you and California FarmLink for providing this amazing learning experience. My working knowledge of QuickBooks and accounting for small businesses in general has increased exponentially. I can't express how helpful it's been to have one-on-one training and personal support during this first year of production. I'm so grateful for your services and can confidently say that if it weren't for your financial and moral support I would not have had the successful year I did."
- At least 25 of these growers increase their profit.
    - 17 of the 45 specialty crop growers completing the follow-up evaluation reported an increase in profit.
- 3 regional specialty crop growers' groups are formed with advisory teams that include experienced farmers, financial professionals, and a marketing professional.
    - Specialty-crop growers in each region, including several established groups of growers, were provided with individualized advisory teams. Teams were comprised of California FarmLink staff, experienced specialty-crop farmers, accountants, bookkeepers, marketing professionals, social media professionals, and farm financing specialists.
- 30 new land lease, partnership or farm succession opportunities are made available.
    - 93 new land lease, partnership, or farm succession opportunities were made available throughout this project (63 more than FarmLink had originally proposed).

Performance Measures with Targets:

- 50 specialty crop growers demonstrate significant increase in knowledge of the topics described above from their initial participation to the end of the project.
    - 45 reported significant increase in one or more topics, including financial goal-setting, cash-flow management, business planning, record keeping, building/repairing credit, creating/implementing enterprise budgets, assessing profitability of sales outlets, marketing planning, and leases/land tenure. More than 20 increased knowledge significantly of farm financing; 15 were able to receive loans.
- 25 specialty crop growers increase sales of specialty crops by at least 15%.

- 22 of the 45 responding growers reported an increase of sales over the one-year period that was tracked. One participant who had received direct assistance from a project consultant increased sales by 58%. Three increased sales by 35% - 40%. Two increased sales by 16% - 20%. Five increased by 11% - 15%. Six increased by 6% - 10%, and two increased by 1% - 5%.

- 25 specialty crop growers hire one or more employees
  - Of the 45 respondents, 8 growers were able to hire new employees, for a total of 16 new employees.
- 30 new land lease, partnership or farm succession opportunities are available to specialty crop growers.
  - 93 new land lease, partnership, or farm succession opportunities were made available throughout this project (63 more than FarmLink had originally proposed).
- 25 specialty crop growers secure land tenure.
  - 58 specialty-crop growers secured land tenure throughout this project.
- 9 specialty crop growers expand their operations by obtaining financing.
  - 16 growers were able to expand their operations by obtaining financing.

Goal: 50 specialty crop growers increase their knowledge of land tenure, farm leases, farm financial management and financing, and business and marketing planning

- 61 specialty crop growers participated in this project, with 45 completing the follow-up evaluation and reporting increase in knowledge in the topics described above.

Goal: at least 25 of these growers increase their profit

- 17 of the 45 responders reported an increase in profit.

Goal: 3 regional specialty crop growers' groups are formed with advisory teams that include experienced farmers, financial professionals, and a marketing professional

- Most of the work with specialty-crop growers was accomplished with individual growers, rather than in groups. However there were 3 distinct groups that participated in this project: one in the Central Valley; the cooperative farmer group in the North Coast; and the Bay Area Chrysanthemum Growers Cooperative Association in Santa Clara County. Farmers in this project, individually or as part of a group, received intensive TA from FarmLink regional coordinators and loan officer, as well as from collaborators and consultants, including SELC, KTA, a farm consultant, and a small farm business advisor.

Goal: 30 new land lease, partnership or farm succession opportunities are made available

- 93 new land lease, partnership, or farm succession opportunities were made available throughout this project (63 more than FarmLink had originally proposed).

Baseline data included information about growers' acreage, crops, marketing outlets, sales, profit, record keeping, and employees. Baseline data was also gathered about participants' levels of knowledge in financial goal-setting, cash-flow management, business planning, record keeping, financial statements, business mission and vision, building and repairing credit, creating/implementing enterprise budgets, assessing profitability of enterprises, assessing financial needs, obtaining financing, assessing profitability of sales outlets, marketing planning, and leases/land tenure.

Twenty-two participants showed significant progress in increasing sales; 17 showed progress in increasing profit. Fifty-eight participants obtained leases for new ground, enabling those growers to begin or expand an operation, and 16 obtained financing, many for the first time, enabling growers to meet production expenses and invest in needed equipment and infrastructure.

Here are two stories that highlight successful outcomes:
One specialty-crop grower owns a farm in Sebastopol that had very inadequate systems to run the business. The grower did not use QuickBooks or Excel to track income, expenses or accounts receivables; had boxes and folders of receipts and invoices; and did not know how much money was made or if customers had paid everything that was owed. After receiving TA on recordkeeping systems in early 2013, the grower met with KTA to start harvesting business and financial information to help with the 2014 crop plan and budget. Armed with sales information by crop and by customer (for example, the grower now knew how many cases and how many dollars of beets were sold to Whole Foods), the grower worked with KTA staff on a financial analysis to identify crops that were financial winners and losers. With increased knowledge about productivity and soil-building goals, the grower made more informed planting decisions for 2014. The worst performing crops were eliminated and production was increased on the best performing crops. A 25% increase to the grower's net income is projected based on these decisions.

Another specialty crop grower who received TA owned and operated the farm with a partner. In 2013, one partner decided to leave the business, and the other partner wanted to continue running the farm. The remaining partner was excited about the prospect of having full control of the business, but was daunted at having to manage all aspects of this complex small farm business. KTA provided regular TA to help the grower evaluate business changes; time management; people and systems needed to continue to operate the farm; and financial implications of these decisions. KTA also provided a sounding board as the owner made other key decisions. Farm partnership dissolution can often result in the demise of small farms; this program provided in-depth technical assistance at a key inflection point in this business to increase the likelihood of success.

Beneficiaries

The specialty-crop growers who benefited from the completion of this project's accomplishments are small-scale growers, with acreage ranging from 1 to 200 acres. Most grow mixed vegetables as their primary crop; other significant crops include berries, wine grapes, orchard crops, flowers, and herbs. Many are beginning, limited-resource, and minority specialty crop growers.

61 specialty-crop growers participated in this project, including a collaborative farm of six farmers that was considered as one unit. Of the 61 specialty-crop grower participants, 45 growers completed the project and 52 received individual TA with more than one professional. These professionals included experts in recordkeeping, business planning, marketing and social media, financial management, and accounting/bookkeeping/Quickbooks, in addition to the in-house expertise at FarmLink on land tenure and farm financing. 22 of these growers showed an increase in sales, 17 showed an increase in profit, and 8 were able to hire 16 new employees. 58 specialty-crop growers secured land tenure, and 16 growers expanded their operations by obtaining financing. The experience shows that the majority of these growers who have stabilized and expanded their businesses will continue to grow and increase success in the future. In addition, growers attended workshops, mixers, and other events that were conducted through this project; evaluations

show that a majority of attendees received valuable knowledge and resources including lease and land tenure expertise and farm financing training that will be used in the future.

Lessons Learned

FarmLink learned many lessons from this project, particularly that an individualized educational approach was more effective for each farmer than the original approach to have groups of growers formed into learning communities. The individual attention each farmer received from the consultants proved highly valuable, efficient, and effective. Use of workshops and mixers proved to be an effective and efficient way to provide important education and resources to a large number of growers. A number of resources, including the *Introduction to Income Taxes for Small Farms* webinar, and the workbook, *Small Farm Tax Organizer*, were very effective, and will continue to deliver important knowledge and training. The fact sheets, spreadsheets, *Business Plan Workbook*, and Spanish-language resources were also very effective, and provide continuing resources for growers.

Project staff learned a valuable lesson regarding ways to approach more effective collaboration with participating farmers in completing and following up with the evaluation process, since participation in exit evaluation was not as high as expected. One approach for the future is to enlist the farmers' consent and agreement to participate in both baseline and follow-up/exit evaluations prior to beginning work, and to create a schedule for this process early in work with the participant. Many participants who started the project proved difficult to reach later on, with some never replying or responding. This is generally due to the time demands on specialty crop farmers in California, especially during peak growing seasons, as well as unclear expectations regarding all elements of participation in this project. These issues will be addressed in ways that are productive and workable for growers and staff.

FarmLink reviewed and analyzed the reasons for the outcome targets that were not achieved, including the number of farmers slated to show an increase of 15% in sales, and the number of growers able to hire new employees, and learned that a longer time-frame is needed to deliver the technical assistance and resources in order to meet those levels of increase.

Working on this project helped California FarmLink staff better understand the types and combinations of educational models that work well for the specialty-crop growers that the organization works with.

USDA Project No.: 12	**Project Title:** Linking Nutrition Education with California Grown Specialty Crops Statewide	
Grant Recipient: California Alliance with Family Farmers	**Grant Agreement No.:** SCB12012	**Date Submitted:** December 2015
Recipient Contact: Diana Abellera	**Telephone:** 510-832-4625 Ext.14	**Email:** abellera@caff.org

Project Summary

According to the California Department of Education, 74% of youth are unfit, and 51% eat a maximum of 1 fruit or vegetable serving each day. While many school districts are teaching about nutrition and healthy eating, students are unaware of the where their food comes from and who grows the food. At the same time specialty crop growers are struggling to stay in business and are looking for new markets. Community Alliance with Family Farmers (CAFF) conducted one study in which 66% of specialty crop growers said they needed help in connecting with new local markets. To address both issues, Farm to School programs increase access to healthy, locally sourced food while also educating students about nutrition and agriculture. The Farm to School movement has grown throughout the state and nation, and school districts are interested in starting or growing their local sourcing efforts. Since the Harvest of the Month (HOTM) program only features one fruit or vegetable a month, it offers an easy opportunity for school districts to try sourcing local growers.

Since 2001 the CAFF has run Farm to School programs that increase specialty crop consumption, improve student knowledge of nutrition and agriculture, and generate a steady revenue source for California farmers. The Network for a Healthy California developed a Harvest of the Month curriculum that school districts use throughout the state, featuring a California fruit or vegetable each month to promote nutrition and healthy eating. CAFF's has worked since 2006 to connect the HOTM curriculum to California specialty crop growers by purchasing directly from those growers and marketing them to students so they know who grew the food and where it was grown. CAFF's HOTM Tasting Kit program delivers packages of nutrition and local food systems curriculum, farmer profiles, and featured varieties of seasonal produce to classroom teachers each month. The program originated on the Central Coast, serving over 10,000 students in 500 classrooms across 5 counties. As thousands of teachers in other regions use HOTM curriculum, they have repeatedly asked for CAFF's assistance in connecting with local sources of the featured produce. Thirteen school districts had already asked CAFF for support in learning from the HOTM model and enhancing local procurement efforts. This project set to replicate the CAFF's HOTM Tasting Kit program in Sonoma County and work with 5 Network's statewide partners to connect their HOTM programs to sources of California grown specialty crops. The project goal was to enhance California specialty crop awareness and education through replicating the HOTM Tasting Kit model statewide. The project objectives were to 1) create a HOTM Local Procurement Toolkit, 2) launch a HOTM tasting kit program in Sonoma County, and 3) provide technical assistance to 5 Network partners statewide by linking their existing HOTM programs to local farms and specialty crop sources.

This project built upon a 2010 grant, Project # 30, the University of California, Davis' (UC Davis) "Building Successful Farm to School Models to Enhance Markets for Specialty Crops." UC Davis contracted to Oakland Unified School District (OUSD) and CAFF to implement Farm to School programs. OUSD was one of 3 districts UC Davis was working with to evaluate different methods of increasing procurement of California specialty crops in various geographic settings and different sized school districts. During a project meeting, the Enterprise School District in Redding, California presented on their HOTM program. The district purchased their fruits and vegetables from a big box retailer and was not able to identify the source of the product. CAFF followed up with Enterprise and discovered that the district, as well as many other districts that implement HOTM programs, did not source locally or directly from California farmers. However, many of these districts wanted to use their HOTM programs to connect directly with local specialty crop growers. As a result, CAFF developed this project to continue the efforts started by UC Davis' project and expand local sourcing efforts to other school districts and programs throughout the state.

Project Approach

The work plan was designed around 3 objectives. Below is a summary of the activities accomplished under each objective.

Objective 1) Create a HOTM Local Procurement Toolkit:
The Toolkit, called "Sourcing Fresh and Local: Incorporating California Grown Specialty Crops into Your HOTM program," was created and designed based not only on CAFF's program model, but also incorporating elements and ideas from other programs around the state. The Toolkit was distributed to 5 partners in different regions throughout the state to use as they began to purchase California specialty crops for their program in year one of the project. Feedback was collected and incorporated, and the final Toolkit was completed and published in the summer of 2014. The Toolkit was been posted to the CAFF and CA Farm to School Network websites, and staff have delivered presentations that promote the Toolkit. The web link to the Toolkit is provided at the end of this report under additional information.

Objective 2) Launch a HOTM tasting kit program in Sonoma County:
CAFF successfully replicated the Central Coast HOTM Tasting Kit program in Sonoma County by hiring and training a project coordinator, developing relationships with California specialty crop producers in the region, and running the program for 2 years and 3 months. Each month, staff ordered produce from a local farmer, developed a farmer profile and nutrition education materials, packed, and sent boxes of the curriculum, and sample specialty crops to hundreds of classrooms. The program delivered to 238 classrooms in year 1 and 354 classrooms in year 2.

Objective 3) Provide technical assistance to 5 Network partners statewide by linking their existing HOTM programs to local specialty crop farms and produce sources:
This objective was the most challenging part of the project due to external circumstances. Between the time that CAFF applied for the grant and the grant was awarded, the Network for a Healthy California shifted funding away from schools. As a result, many of the partners that wanted to enhance their existing HOTM programs to incorporate California grown specialty crops no longer had funding to run their programs. As a result it took longer to choose and finalize partners that would be able to participate in the project. However, the project team was able to identify 5 partners, conduct site visits, and provide support in helping them procure local specialty crops for their programs. The program team decided not to bring together partners for an in-person meeting, as it was much more beneficial to them for CAFF staff to provide more ongoing

technical assistance and travel to each of the partners. Each of the 5 partners was successful in utilizing the partnership to increase their procurement of local specialty crops for their HOTM programs.

The project was solely focused 100% on specialty crops, as the HOTM program items are only fruits, vegetables, and nuts that are California grown, and has been monitored by CAFF through documentation and accounting.

Key partners in the project were the 5 subcontractors:

- Del Norte Unified School District
- Middletown School District
- University of California San Diego Department of Pediatrics
- University of California Cooperative Extension, Stanislaus Merced
- El Dorado Hills Community Vision Coalition

Each of these partners contributed by working with CAFF to incorporate California grown specialty crops into their school districts HOTM programs. Previously, each of the partners was purchasing fruits and vegetables without regard to where they were grown or seasonality, purchasing from retail stores or big box stores without being able to identify which farms and growers had provided the products. CAFF helped each partner develop a calendar that was seasonal to the growing climate in their immediate region and identified farmers and distributors to source from. Key in this process was ensuring that the buyer was able to verify where the featured specialty crop was grown and promote the grower to students tasting the product.

Another partner instrumental to the success of the project was FEED Sonoma, a regional distributor in Sonoma County that delivered the HOTM tasting kits to schools. Each month they allowed CAFF to pack the kits in their warehouse space, and FEED Sonoma would distribute the kits to the participating schools throughout the county.

Goals and Outcomes Achieved

CAFF had 2 major objectives that were set to measure throughout the project. Below are the activities implemented to help measure the program objectives:

1) At least 5 existing HOTM programs from around the state will shift from featuring unidentified produce to featuring 100% California grown specialty crops in season:

CAFF determined baseline levels of the percentage of California specialty crops each of the partners was sourcing for the current HOTM programs at the beginning of the project. Each of the partners provided the HOTM calendars and sources of their specialty crops throughout the project period. CAFF measured changes from the beginning to the end. When possible, some programs provided costs spent on the specialty crops featured each month; however, reporting consistently on dollar figures was difficult. CAFF was able to verify the farm and location from which the featured specialty crop was sourced from each month over the course of 2 years.

2) At least 50% of students receiving the programming will display an increase in knowledge of California specialty crops:

CAFF conducted pre and post-tests with students in the Sonoma County HOTM Tasting Kit program and asked each of the 5 partners to conduct pre and post tests to measure their knowledge of California specialty crops.

The outcomes were measured during the project period. In addition, each of the 5 partners has set their calendars for the upcoming 2015 – 2016 school year and is continuing to source 100% solely California specialty crops from local growers.

All of the outcomes and objectives were achieved during the project period. CAFF developed a HOTM Local Procurement Toolkit, launched a HOTM Tasting Kit program in Sonoma County, which is about to start its third year, and has assisted 5 HOTM programs throughout the state in sourcing locally grown California specialty crops.

Below is a table the details each of the 5 partners' baseline levels and how their programs have shifted throughout the course of the project.

Partner Name	**Baseline**	**Actual Outcomes**
Del Norte Unified School District	About 20% purchasing from California Specialty Crop growers	Almost 100% of the products purchased are California grown specialty crops. Calendar is based on fruits and vegetables that are local and seasonal to Del Norte County.
UC San Diego Department of Pediatrics	0% - HOTM program is new	100% of the products purchased are California specialty crops. Many are sourced from San Diego County.
UC Extension Stanislaus Merced	About 40% purchasing from California Specialty Crop growers	100% of the products purchased are California specialty crops. Many are from Stanislaus County.
El Dorado Hills Community Vision Coalition	0% - HOTM program is new	100% of the products purchased were California specialty crops, such as berries, kale, and radishes.
Middletown School District	Some Lake County grown, but funds have been a barrier	100% of purchasing is from local California specialty crop growers. The program is purchasing all products from the Mendo-Lake Food Hub, which sources solely from California growers.

For the second outcome, CAFF distributed pre and post surveys to students participating in the program. The 5 partner districts surveyed sample sizes of students participating in the HOTM program. 312 pre-tests and 189 post-tests were completed. When asked how often students like to try new fruits and vegetables, there was a 9% increase (from 63% to 72% of students) who responded "a lot" from the pre to post test data. Additionally, at least 50% of students demonstrated increased knowledge of seasonality and crops that grow in California through identifying California grown products. For example, more students were able to identify the specialty crops grown in California in the post-test than pre-test. In addition, more students knew that pineapple does NOT grow in California in the post-test than the pre-test.

Knowledge of California Specialty Crops

Item	Pre-Test % Correct	Post-Test % Correct
Apple	80%	86%
Broccoli	47%	64%
Pineapple	73%	80%
Lettuce	73%	78%
Average Correct Answers	**68.25%**	**77%**

The major outcomes of the project are:

- 5 partners shifted their HOTM programs to be almost 100% sourced from California specialty crops.
- 77% of students displayed knowledge of California specialty crops at the end of the project, an 8.75% increase from 68.25%.
- The percentage of students who said they liked to try new fruits and vegetables "a lot" increased from 63% to 72% throughout the project period.
- More than 50% of students participating in the HOTM programs demonstrated increased knowledge of California specialty crops.
- More than 50 specialty crop growers sourced to the six HOTM programs. Previously, three of the programs did not exist and the other three were sourced from unidentified sources.
- At least $28,000 was spent by the five partners and the Sonoma County HOTM program to purchase California specialty crops.

Beneficiaries

More than 50 specialty crop growers were the primary beneficiaries of the project. The 5 partners and the Sonoma County HOTM program all purchased specialty crops from local growers. These growers have been able to plan crops according to the HOTM calendars the partners developed during the summer and have secured sales from local school accounts. In addition, the specialty crop farmers were marketed in the classrooms with farmer profiles so students were able to identify who grew the food. One grower from Bloomfield Organics remarked:

"At Bloomfield Organics it's rare to find a true partner that helps our family farm survive and thrive. And CAFF is one of the few organizations that we truly call a partner. As a member of CAFF we receive a ton of value, both measurable and immeasurable. First, CAFF helps us sell! We have recently formed a partnership with the Santa Rosa City Schools, which is incorporating our produce into their farm-2-school meal program. As a farm looking to make a difference in the community and make a living this partnership is great because we are able to earn consistent high-volume business at a fair price and, at the same time, make sure the next generation is getting the good stuff!"

Distributors such as the Mendo-Lake Food Hub and FEED Sonoma were also able to generate business and establish more relationships with local specialty crop growers as a result of the project.

School districts greatly benefited from the project as they started new or adapted existing HOTM programs in the classroom. Schools were able to incorporate more nutrition education and agriculture into the classrooms and also connect with offerings in the cafeteria so that at lunchtime students would eat what they learned about during class.

Finally, thousands of students throughout the state learned about and tasted California specialty crops in the classroom. They also learned about which farmers grew the fruits and vegetables that they tasted.

California specialty growers from various regions throughout the state have been able to secure sales from all 5 partners on the grant and the Sonoma County program. At least $28,000 of sales receipts were reported to CAFF at this time, and the impact is much greater as not all programs reported monthly purchasing totals. For example, University of California, San Diego only reported $267 of sales from a few months of the program since they began sourcing from California specialty crop growers in February 2013. However, they only started with providing samples to 3 schools and have since expanded to 84 schools and have purchased from California specialty crop growers for over 2 years of the program. In addition, San Diego Unified School District (SDUSD) has complemented the program in the classroom by also sourcing the products in the cafeteria from California specialty crop growers. One month, local specialty crop sales were reported as $43,340.50 in the cafeteria! Because SDUSD is the second largest school district in the state, the opportunity for the HOTM program in the classroom to coordinate with cafeteria sales has great impacts for California specialty crops.

FEED Sonoma reported that in one year they sourced at least $18,000 of California specialty crops for the Sonoma County HOTM program.

Each of these programs are continuing beyond the grant period and will continue to source from California specialty crop growers, generating hundreds of thousands of dollars for growers.

Lessons Learned

The major lessons learned was that the project team needed to create more formal partnerships with project partners to get evaluation data throughout the project. Partners were grateful for support, financial assistance, and materials that CAFF provided, but it was difficult to get financial data for each month on spending when the team was only providing a couple of months of funding. CAFF wanted partners to sustain efforts in sourcing from local specialty crop growers on their own, and when they were able to accomplish this feat they did not report financial data to CAFF. In the future the project team will provide more funding for their time and contributions to evaluations, and this can be agreed upon by providing data for evaluation purposes into Memoranda of Understanding.

In addition, it would have been beneficial to allocate funds to hire a professional evaluator as a subcontractor. Determining students' knowledge of California specialty crops and their changes in knowledge after a program intervention requires a well-designed evaluation plan. Question design and methodology in implementing the pre and post surveys would have helped the program team to navigate the data and ensure CAFF is able to measure the changes accurately. In the future the project team will include evaluation subcontractors in grants with adequate funding to help design the tools, implement the tools, and analyze the data.

The biggest challenge in the project occurred in finding committed partners to the project. When the initial proposal was written, dozens of school districts that were implementing HOTM in the classroom were interested in learning how to source their programs from local California specialty crop growers. However, before the grant was awarded, the majority of the programs lost funding from the state. As a result, the programs were focused on determining funding their existing programs, not on enhancing them by sourcing locally grown specialty crops. As a result, the project team was able to help some of the programs to change their models so that they incorporated more sustainability through generating revenue, utilizing distributors, and recruiting volunteers.

CAFF has also been able to generate program income in the amount of $8,290 which was reinvested back into the project and into the Sonoma County HOTM Tasting Kit program so that it is moving towards financial sustainability. The grant allowed the program the opportunity to get started in the region, gain school enthusiasm and support, and prove to local specialty crop growers that the program can help secure grower sales and market themselves locally. As the program continues into its third year, over 70 schools are already signed up for the 2015 – 2016 school year, paying $15 per kit each month. This model and money goes back to the schools and allows HOTM to operate the program.

All program goals and outcomes were achieved.

Additional Information

CAFF's Harvest of the Month Tasting Kit web page: http://www.caff.org/programs/fts/hotm/

CAFF disseminated the program results and promoted the HOTM Local Procurement Toolkit through the following webinar: http://www.caff.org/wp-content/uploads/2015/04/Toolkit-for-PRINT_web.pdf

USDA Project No.: 13	**Project Title:** Branding Sonoma County Wines	
Grant Recipient: Sonoma County Winegrape Commission Local District 3	**Grant Agreement No.:** SCB12013	**Date Submitted:** December 2015
Recipient Contact: Karissa Kruse	**Telephone:** (707) 522-5863	**Email:** Karissa@sonomawinegrape.org

Project Summary

Demand for wines over $15/bottle weakened in this economy in 2012, affecting almost all Sonoma wines. Wineries push price drops to growers as contracts are renewed, causing an average $157/ton (7%) decrease between 2008 and 2011 ($31.4 million based on 5 year average tonnage). Accordingly, an average of 19,600 tons per year of Sonoma's 6 leading varieties was sold for less than the growers' average breakeven cost from 2008 to 2010. Sonoma County Winegrape Commission's (SCWC) purpose is to recover a large portion of the lost grower return. Research from Wine Opinions from several years ago indicated that 68% of wine consumer's associate Sonoma County with value and high quality wines, and market indicators show consumers are starting to trade back up. SCWC challenge has been that only 11 of 18 Sonoma American Viticultural Areas (AVAs) include "Sonoma" in the names, making it difficult to develop uniform campaigns to take advantage of Sonoma's widely-held image for quality and value. Sonoma wines were recently required by California law to include "Sonoma County" on the labels, making uniform and broad-scale promotion of the value already perceived by wine consumers possible. SCWC goal is to leverage Sonoma County's reputation with an advertising partnership with Food & Wine magazine, online and print media advertisements, and on and off-premise sales promotions with local wineries, retailers, and restaurants. SCWC will also develop an online winery locator to drive consumer wine purchases direct from Sonoma wineries; consumer direct sales are critical to many grower/vintners. The locator will allow users to find wines to purchase wineries from a set of criteria such as variety, wine style, region, winery name and more. SCWC objective is to recover 20% of the decline in grape prices experienced since 2008 for an estimated $6.3 million in additional grower returns annually.

Additionally SCWC aimed to reduce the tonnage sold below the breakeven point by 50%, meaning that an additional 9,800 tons of grapes would increase to profitable pricing levels.

The importance and timeliness of this project cannot be overstated. When this project started in 2012, a new California state law was going into effect called conjunctive labelling that required wineries to put "Sonoma County" on the label. This created more unity for the region and helped build brand equity for Sonoma County wines and preserve and strengthen Sonoma County's position as a recognized world-class wine region with approximately 100 million bottles on store shelves and restaurant wine lists with Sonoma County on their label. This market exposure for Sonoma County helps increase the demand and value for Sonoma County grapes, thus creating a positive marketplace for grape growers to sell their fruit each harvest.

In addition, the SCWC in partnership with Sonoma County Vintners and Sonoma County Tourism, unveiled a new branding campaign called "We Are Sonoma County" that included a new brandmark and logo designed to unify marketing efforts and build more awareness for Sonoma County as a winegrowing destination. Funds from this project allowed SCWC to develop and execute marketing initiatives that furthered this program and partnership, while also helping SCWC increase exposure for the value and positive perception of grape growing. The timing of this project allowed SCWC to continue to build on the momentum of this partnership and marketing program. Many of the advertisements and partnerships with key media publications, such as Food & Wine and Wall Street Journal resulted from this project.

Finally, 2013 and 2014 saw two of the largest grape crops on record for Sonoma County, in terms of total tonnage. This resulted in more grapes on the market, yet, demand continued to increase. The timing of this project allowed SCWC to continue to market Sonoma County grapes directly to the influential buyers of grapes, including wineries, winemakers, brokers, and others. Having these funds during this timeframe was vital in SCWS's efforts to build awareness and demand for Sonoma County grapes that helped create value back to grape growers who had more fruit to sell in 2013 and 2014 than during normal, average harvest seasons.

This project did not build on previously funded SCBGP project.

Project Approach

The SCWC is very proud of the work accomplished and the successes as a result of this project. What follows is a summary of those tasks, accomplishments, and other details.

1. Online Winery Locater: In partnership with Sonoma County Vintners and Sonoma County Tourism, with technical assistance by Asterix Group, SCWC developed, designed, built out, and beta tested an online portal that allows consumers to search for their favorite Sonoma County wines based of personal preferences, such as varietal, style, price, AVA, occasion, vineyard, and more. This web portal, called "Wine Finder" was launched to the public in early 2015 on the organization's share website at www.wearesonomacounty.com/winefinder.

   It is also important to note that this was a huge project with a lot of moving parts that required a lot of technical and IT expertise. For that reason, this task in the project took longer to complete than anticipated, yet the results are impressive and speak to the importance of this new online tool and its impact on Sonoma County's brand campaign and has helped increase awareness for grape growers in Sonoma County.

   Since launching, this Wine Finder tool ranks as the most visited section of the website. There are more than 300 wines entered into the main database that houses all the information, with new wines and vineyards being added weekly. Grape growers have also started using this site to help market their grapes by sharing it with clients and advocating for the tool so that more wines sourced from those vineyards will be entered into the system, resulting in more direct sales from consumers. Ultimately, that will help increase demand for Sonoma County wines and grapes. This online winery locator will continue to be a major platform and tool for future branding efforts and allow project staff to better connect with consumers. It also allows staff to do more digital advertisements, which is something that allows staff to expand the resources created from this project into the next phase of the marketing and branding efforts for Sonoma County.

2. Food & Wine Magazine: In collaboration with Sonoma County Vintners, Sonoma County Tourism, Sonoma Valley Growers and Vintners Alliance, Winegrowers of Dry Creek Valley, and others, SCWC

created a multi-year, national advertising and promotional campaign with Food & Wine Magazine, which is one of the most widely read epicurean and wine magazines in the world. It's also one of the most respected and relevant magazines for consumer audiences of wine, so this partnership was a perfect for Sonoma County and the brand campaign launched to build awareness for the region. With creative direction from Asterix Group, SCWC created, designed, and purchased seven full page print ads over a two year period that depicted Sonoma County's brand identity, including grape growing, vineyards, winemaking, and other aspects that set the region apart. These print ads reach more than 8 million readers per issue, for approximately 50 million impressions over the duration of this advertising campaign. In addition, SCWC participated at Food & Wine Magazine's Classic in Aspen in 2013 and 2014. As the largest and most respected food & wine event in America, this event allowed Sonoma County to reach more than 5,000 wine consumers, media, and influential wine trade buyers, including sommeliers, wine retailers, winemakers, and others. In addition, SCWC participated at the 2013 Food & Wine at Pebble Beach event, reaching 1,000 consumers, media, and influential wine trade. Food & Wine Magazine continues to become one of the most credible, influential publications for consumers looking to make wine purchasing decisions. SCWC will continue to partner with this magazine because it's the best way to reach the target audience and build value and demand for Sonoma County, it's vineyards, and grape growers.

3. Target Market Advertising: SCWC created a comprehensive advertising campaign to promote Sonoma County winegrowers and wines to consumers in target wine markets across the county to build awareness for Sonoma County wines, drive purchase at local wine retailers and restaurants, and increase consumer attendance at local Sonoma County events, such as the SCWC's annual Grape Camp harvest experience program. These efforts resulted in the creation, design, and purchase of print advertisements in more than 15 media outlets with a national, regional, and local consumer reach over the course of this 2 year project. This included Wine Spectator, The Wall Street Journal, USA Today Travel, Wine Enthusiast, San Francisco Chronicle, Sonoma Index-Tribune, Horizon Magazine, Sonoma Magazine, The Press Democrat, The Windsor Times, The North Bay Bohemian, Sonoma County Visitors Guidebook, and others. These advertisements and brand awareness campaigns garnered a combined readership of more than 50 million. In addition, these efforts helped SCWC sell out of the annual Grape Camp consumer experience months in advance during the project, in fact, creating demand and a waiting list for 2015 and 2016 program events.

4. Grape Trade Advertising: SCWC developed, created, and purchased a series of print ads in vineyard and winery trade publications to increase awareness of the quality of Sonoma County grapes, as well as increase sales and value of grapes in the region. These ads conveyed the value of vineyards and grape growers and told their story and impact in the industry. The print ads were also intended to support the Grape Marketplace, an online portal allowing grape growers to sell their winegrapes and connect with potential new buyers of grapes. Print ads were purchased in Vineyard & Winery Management Magazine, Practical Winery & Vineyard, Wine Business Monthly, Wines & Vines Magazine, and the event program for Unified Wine & Grape Symposium, the nation's largest wine industry trade event. These efforts increased awareness and branding for Sonoma County Winegrowers, allowed SCWC to position Sonoma County grape growers as leaders in agriculture, sustainability, and as a quality source of premium winegrapes. The campaign also helped increase grape pricing year-over-year and demand is on the rise.

   These efforts were also instrumental in helping build momentum and morale for grape growing in Sonoma County. One of the grape trade advertisements, called "Our Creed" created a lot of pride among the grape growers in Sonoma County. Though this was not one of the project goals, this development helped increase momentum and support for these marketing efforts and this project, which is an important aspect of this work.

5. On/Off Premise Sales Promotion: SCWC created an on-off premise sales promotion with Binny's Beverage Depot (Chicago, IL) to introduce customers to Sonoma County wines, drive purchase or trial through special pricing, promotional point of sales materials, and in-store education. This activity, done in collaboration with Sonoma County Vintners and Sonoma County Tourism, comprised of a retail partnership with Chicago's largest wine retailer, including 31 stores throughout that city's metro area. This month long retail promotion was from March 1-31, 2015 and included a comprehensive staff training for more than 200 people, in-store tastings for consumers, creation of Sonoma County Branding and Point of Sale Material, End Cap Displays in store, special sales and discounts on Sonoma County wines, and promotions that focused on grape growing practices and sustainable farming. In addition, there was an in-store tasting for consumers at four Binny's locations that featured 17 winemakers and winegrowers pouring Sonoma County wines and sharing their stories of winegrowing in the region. As a result, these efforts created more branding and awareness for Sonoma County, its vineyards and wines, throughout the metro area of Chicago. In addition, there was a 7% volume increase in the Sonoma County wine category; a 10% revenue increase for Sonoma County wines; out of the 58 Sonoma County wines featured, there was a 34% growth in volume sold, along with a 33% increase in revenue for March 2015, compared to that same sales period in 2014.

   One of the major conclusions from this aspect of the project was that it takes much more time than anticipated to identify the right on/off premise partnership and finalize details of the program. This promotion was delayed due to SCWC searching for the right partnership based on the stated goals and to ensure the program brought direct value back to grape growers. After careful thought, planning, and execution, SCWC created a very successful On/Off Premise Sales Promotion that focused on grape growers, built awareness for Sonoma County and its wines in one of America's largest and most recognized wine consumer markets.

Throughout the project SCWC ensured that funds were used to solely enhance the competiveness of specialty crops by making grape growing and grape growers a central focus of promotional efforts and always reinforcing the value of grape growing in Sonoma County. This was done by using photos of vineyards and grape growers, explaining the dedication and hard work that it takes to produce quality wine grapes, and promoting the key facts and attributes of Sonoma County's grape growers.

SCWC were fortunate to have a number of partners that were instrumental in the success of this project. They included:

- Sonoma County Vintners: This organization that represents hundreds of wineries throughout Sonoma County were instrumental in efforts with this grant project. Many of the target market print advertising and promotions were done in partnership with them, including developing campaign themes and key messages, staff resources and expertise, as well as development of media partnerships with Wall Street Journal and Food & Wine Magazine, among others. This efforts also allowed both organizations to leverage their combined budgets monetarily to make it a larger impact. In fact, SCWC could not have advertised in some of these publications without leveraging budgets and combining efforts and staff of both organizations. In addition, Sonoma County Vintners were great partners in the creation of the

Winery Locator tool that creates an online database of wines that consumers can find and purchase based on important criteria, such as price, varietal, vineyard designate, and more. They provided access to their members to build out the database with wines and also beta test the functionality and ease of use both for consumers, and on the backend where the information is added to the online tool. Finally, they were helpful in communicating results and project progress to their members, community, and other industry representatives.

- Sonoma County Tourism: Representing the tourism businesses of Sonoma County, such as hotels, restaurants, tour guides, and others, this organization was instrumental in providing expertize and additional funds to support the print advertising campaigns, including the Wall Street Journal partnership. They also provided staff resources and expertise during the development of promotional material and gave SCWC access to their database of artwork, photography, and other assets that helped with the creative development. In addition, they were instrumental in the development of the Winery Locator by partnering with SCWC to use their existing database platform, SimpleView, for the project. This saved thousands of dollars and also provided staff with a reliant, already proven technology system that is the engine and brain of this wine locator tool. This important tool allowed staff to populate all the relevant information about Sonoma County wines, vineyards, and other details that consumer need to make online wine purchasing decisions.
- Sonoma Valley Vintners and Growers Alliance & Winegrowers of Dry Creek Valley: Both of these organizations represent hundreds of grape growers and wineries in Sonoma Valley and Dry Creek Valley viticulture areas of Sonoma County. They were instrumental in a number of ways, including participating in a cooperative marketing effort that featured both regions in a print ad with the Sonoma County brand mark and messaging. This partnership allowed SCWC to expand marketing efforts and build more awareness for grape growing in Sonoma County in Food & Wine Magazine, as well as several other publications and at consumer, wine trade, and community events. Finally, both organizations were helpful in communicating results and project progress to their members, community, and other industry representatives.
- Wine Institute: This organization representing California's wine industry was helpful to the project by promoting SCWC efforts to their membership and incorporated SCWC brandmark into their own communications during California Wine Month activities. In addition, they brought new advertising and promotional opportunities, such as the San Francisco Chronicle special California Wine Month insert that allowed staff to place an ad promoting winegrowing and winemaking in the region.
- Asterix Group: This creative agency was instrumental in the development and creation of the advertising and print campaigns, including design, messaging, and branding. They helped staff identify the key messages and designed the campaigns to best convey those messages and showcase grape growing. Asterix Group was also instrumental in the technical aspects of launching the Wine Finder portal, including the format, design, coding, IT support, and other aspects that were needed to launch this online search tool.

Goals and Outcomes Achieved

As stated in the above Project Approach section, SCWC completed a variety of activities to achieve the performance goals and measurable outcomes. The mission of the Sonoma County Winegrape Commission is to increase the value of Sonoma County winegrapes and to nurture and protect this agricultural resources for future generations. One of the goals of this project was to increase pricing of Sonoma County grapes and to build more awareness and demand for grapes in the marketplace. These activities have all contributed to building the demand for Sonoma County grapes and increasing grape pricing and values over the past three years. These efforts have positively impacted and enhanced the competiveness of Sonoma County grapes in the marketplace. They have also helped increase exposure and awareness for grape growing in Sonoma County, the grape growers, and wines.

Another goal was to reduce the amount of winegrapes sold below breakeven production cost; in 2011, there was an estimated 19,600 tons sold below production costs (averaging $1,500/ton) out of approximately 150,487 total tons among the six leading varieties. That shows that roughly 13% of these top six varieties sold below production costs. In 2013, there was 18,382 tons sold below production costs out of approximately 152,540 tons. That is a reduction of approximately 1,218 tons since starting these activities. It's also a 1 percent decrease in the past 2 years. This is significant given the back-to-back bumper crop seasons of 2012 and 2013.

According to the 2013 Grape Crush Report, Table 10 prices, which represent independent grape grower sales, it showed an increase by 3.84% over the previous year. In addition, the average price per ton of grapes in Sonoma County increased more than 15% since 2010, despite two of the largest crops on record. Also, it's worth noting that during the time of this project, the average price per ton of grapes in Sonoma County rose from $2,182.80 in 2012 to $2,318.92 in 2014, a $136.12 per ton average. This is also significant given the increase of grapes available on the market due to larger yields in 2013 and 2014 vintages.

The project's Winery Locator tool had a goal of helping to increase the sales of Sonoma County wines, thus increasing demand for Sonoma County grapes. After launching this tool, SCWC started to monitor the website traffic and other online metrics to determine if consumers were actively using it. The website receives more than 1,000 visitors per month, which was a goal of this project. Staff have also concluded that hundreds of consumers are clicking on the "buy now" link on the individual wine page, signifying that this new tool is helping drive sales and interest to these wines.

The Sonoma County Winegrape Commission also launched a consumer market research survey in the fall of 2014 to measure increases in recognition and association of Sonoma County with AVA's in Sonoma County. One of the goals of the project was to increase the number of consumers that associated various AVA regions with Sonoma County. With conjunctive labeling, and the project's intent to increase awareness for Sonoma County, it was important to ensure consumers associated the AVA regions with Sonoma County. The baseline survey results showed that a majority of consumers recognize SCWC's AVA's as part of Sonoma County. For example, Russian River Valley, Sonoma Coast, Dry Creek Valley and Alexander Valley showed high awareness as being part of Sonoma County. That proves that conjunctive labeling and the brand awareness for Sonoma County created by this project were successful. In addition, the survey concluded that consumers are now more apt to purchase wines in the $15 and above category, which was a project goal. A majority of respondents say they buy wine in the $20 - $30 price category either monthly (32%) or several times a year (35%), which proves that staff are achieving the goals for consumer purchase behaviors. The results also showed that more than half the respondents recognized Sonoma County wines as producing "Excellent" quality wines, which helps support the region's premier status as a winegrowing region. The study also showed that consumers believe Sonoma County wines provides a lot of value for the price point. In fact, Sonoma County was the highest rated region in this category. Finally, the research showed that slightly more than half of respondents believed that Sonoma County offers a diversity of styles and wine flavors.

However, an even stronger indicator of the success of the Sonoma County Winegrape Commission's efforts to brand Sonoma County, thus increasing awareness of grape growers among wine trade and key grape buyers, is the number of wineries that carry a vineyard designate on the wine label. The SCWC surveyed its grape grower members in late 2014 and found that out of 431 responses (representing 35,605 acres of planted vineyards in Sonoma County) more than 238 had sold their grapes to wineries who featured a vineyard designation on its wine label, representing 55% of respondents. That proves that wineries value the importance of grape growing, including a vineyard's place, heritage, owner, and other attributes that make that specific vineyard worthy of being designated or named on the label, which is one of the most visible and important branding platforms for a winery.

In addition, it's worth noting that the SCWC's partnership with Food & Wine Magazine as a result of this project has helped create more opportunities to leverage the brand campaign and increase exposure for Sonoma County and its grape growers. Even though this project is completed, SCWC continues to work with Food & Wine Magazine to expand the partnership and ensure that staff leverage this strong marketing initiative to further increase consumer awareness and demand for Sonoma County wines.

Beneficiaries

The primary beneficiaries of this project were Sonoma County's 1,800 winegrape growers, who are mostly family owned and operated. In fact, 86% of Sonoma County's vineyards are family owned, with 40% of the vineyards being 20 acres or less in size, and 80% of the vineyards being 100 acres or less. So, the beneficiaries of this project are grape growing farmers with small businesses who depend on the work of the Sonoma County Winegrape Commission to help market, sell, and raise values for their specialty crop. Many of these families are multigenerational, therefore, this project was important to help SCWC promote, build brand awareness, and increase the value of their grapes so that their business can endure long term.

Other beneficiaries of this project included the 500+ wineries in Sonoma County that purchase grapes from Sonoma County grape growers, bottle the wine, and sell them to consumers. A majority of the wineries in Sonoma County are also family owned and they are small business.

Tourism businesses, such as hotels, restaurants, and tour companies, also benefitted from this project as the brand awareness created for Sonoma County increased visitors and tourism to the region.

There are thousands of beneficiaries that were positively impacted by the projects accomplishments. With 1,800 winegrowers, 500+ wineries, and over a thousand tourism businesses, it's clear that the project impacted the entire Sonoma County community, which has always been one of the leading agricultural communities in California, and the nation.

From an economic perspective, this project has helped grape growers continue to be the leading driver of the agriculture industry in Sonoma County. Since this project started in 2012, wine grapes have brought more than $1.7 billion dollars in total value to the economy. That represents roughly 60%-80% of the total value of Sonoma County's agriculture industry.

A recent study conducted by Stonebridge Research Group reported the following details about the economic impact of the wine community in Sonoma County in 2012:

- Total economic Impact of the wine community is $13.4 Billion

- Local, state, and federal taxes generated from the wine community is $1.4 Billion
- Sonoma County's wine community generated 54,297 full time jobs, which accounts for 1 in 3 jobs in Sonoma County.

This project will continue to have a positive impact on all these economic indicators by helping build demand in the marketplace for Sonoma County winegrapes and increasing consumer demand for Sonoma County wines throughout the country.

Lessons Learned

Overall, staff learned that developing strong partnerships with organizations with shared values and goals can have a lasting and very positive impact on projects of this magnitude. Support and collaboration with the Sonoma County Vintners, Sonoma County Tourism, and our AVA partners gave SCWC a variety of resources to improve these marketing efforts. They helped improve the brand messages, gave SCWC tips and suggestions on new marketing opportunities, as well as provided a platform for staff to communicate these projects and activities with their members and the Sonoma County wine community as a whole.

SCWC also concludes that consumers and the public are more interested in learning about viticulture, vineyards, and grape growers than ever before. From a lot of qualitative research in talking with media, wine consumers, key wine trade influencers, and others, it's very evident that the branding campaign has spurred a larger interest in understanding what it takes to farm wine grapes. There is a huge interest in the marketplace for information on grape growing. Consumers want to become connected to the soil, to the land, to the vines, and to the interesting, hardworking grape growers that farm their land and work side-by-side with winemakers to produce extraordinary wines that are now recognized around the world. For that reason, SCWC is using this knowledge and trend to better communicate the grape grower story and creating even better marketing campaigns that showcase vineyards and the sustainable farming practices these grape growers utilize to grow premium wine grapes.

There were several delays in the On/Off Premise program due to the focus on finding the right partner to achieve the stated goals. Not only did it take time to identify the right partner, but then it also took time to make sure it would fall under the scope of the project and within the budget and timeline. Extending the timeline allowed SCWC to partner with Binny's Beverage Depot in Chicago, which has become one of the most successful retail partnership that SCWC has ever done. It allowed SCWC to create a retail partnership in one of the key wine consumer markets in the country, as well as time the promotion during another important marketing program that Sonoma County winegrowers and Sonoma County vintners jointly produce called Sonoma in the City. That program took place in Chicago in March, so this partnership with Binny's allowed SCWC to leverage resources and make a much greater impact in the marketplace. In short, it allowed Sonoma County to create a 30 day sales and marketing promotion in March. Had the retail partnership activity not occurred, the Sonoma in the City promotion would have been much shorter in duration and the impact would not have been as large. That's a great example of leveraging components of this project and activities with other marketing functions to create a larger marketing impact with consumers, influential wine trade, and others.

One of the unexpected outcomes or results from implementing this project was an increased commitment and desire by Food & Wine Magazine to increase their partnership with Sonoma County. Since the start of this project, Food & Wine has increased the value added components of the partnership, including allowing access to their Wine Editor, who is one of the most influential wine writers in the world. In addition, Sonoma County was selected to be the exclusive, featured wines at the magazine's Best New Chef event, which is one of the county's most prestigious and sought after events in the culinary and restaurant industry. The event is a who's who of celebrity chefs, influential critics, and other industry luminaries, which allowed Sonoma County to build relationship, brand recognition, and continue to increase momentum for marketing efforts.

In addition, Sonoma County was selected to be the featured wine at Wine Spectator's exclusive Grand Experience Luncheon, attended by more than 2,000 wine consumers, media, and influential wine trade.

Finally, this project helped build momentum and pride among Sonoma County grape growers. The ad campaigns built great awareness for grape growers and agriculture, thus helping staff establish meaningful, lasting relationships and partnerships with the local and regional community, and empowering grape growers to share their farming story, thus helping SCWC build awareness for Sonoma County as the premier wine growing region. It also has helped galvanize the Sonoma County community around helping SCWC preserve agriculture long term and build value for grape growing in this region.

Additional Information

The Sonoma County Winegrape Commission has included a PDF document that provides more context on this project, including website screen shots, photographs of events, print advertisements, collateral material, and more.

USDA Project No.: 14	Project Title: Increasing grower Returns by Marketing Phosphate Substitute for Food Processing	
Grant Recipient: Sunsweet Growers, Inc.	**Grant Agreement No.:** SCB12014	**Date Submitted:** December 2014
Recipient Contact: Stephanie Harralson	**Telephone:** 530-822-2876	**Email:** sharralson@sunsweet.com

Project Summary

The purpose of this project was to increase California prune grower returns with a prune based substitute for phosphates to treat poultry. In 2012 when this program was initiated California prune growers were facing declining sales and rising competition from low cost producers such as Chile and Argentina. Creating new high-value markets for prunes was essential to the health of the California prune industry. At the same time, research conducted at the University of Arkansas showed that prune products provide the same moisture retention benefits as phosphate chemicals, which are used in an estimated 50% of poultry products served in the US.

While the primary purpose was to improve the health of the California prune industry by creating new demand, an important secondary benefit was to remove chemicals such as phosphates from a portion of the US food supply. Phosphates are being consumed in amounts greater than many health professionals are comfortable with, and they pose problems for wastewater disposal.

Global prune prices declined 25% in fiscal year 2010 and 10% in 2011. Unless the price declines were arrested and reversed by developing new high valued markets, the California prune industry faced the possibility of sudden collapse, with growers removing trees to plant other crops and ceding the world market to Chile and Argentina. At the same time, the University of Arkansas study pointed the way towards a very large potential market ready to be developed.

This project was not built on a previously funded SCBGP project.

Project Approach

The key challenge was creating awareness among poultry and other protein processors that an all-natural, reasonably priced, university tested replacement for phosphates was available.

The primary activities used to create awareness were:

1) Direct outreach: Onsite presentations were made to more than 20 important protein handlers. They included Cargill, Tyson, Wendy's, Wegman's, Farmland, Hormel, and Jennie-O, among others. These calls were typically several hours in length and included product preparation and sampling. The team of R&D Culinary conducted the presentations. At the same time, many more potential customers were contacted by phone and e-mail. These leads were harvested from trade show and trade advertising activities, and amount to several hundred contacts made during the duration of the grant.
2) Promotional materials: High quality six-panel brochures were produced and distributed at onsite presentations, trade shows, and by direct mail accompanied by samples.

3) Exhibit at trade shows: Since November 2012 seven major protein-relevant trade shows were attended. These were the Ingredient Food and Technology (IFT) show in July 2013 and June 2014, the International Dairy Deli Bakery (IDDBA) show in May 2013 and May 2014, the Research Chefs conference in May 2013, the Expo West show in March 2014, and the Flavor Event in August 2013. At same time, numerous smaller events, such as the Florida School Show, were attended.
4) Trade advertising: Trade advertising (print & digital) was placed in numerous protein appropriate publications:

Magazine	**Circulation**	**Print**	**Digital**
Meat & Poultry	22,400	Aug ’14, Sep ’14, Oct ’14 Dec’ 14	Jul ’14, Aug ’14, Sep ’14, Oct ’14, Nov ‘14
Food Business News	22,240	Sep ’14, Oct ’14, Nov ’14, Dec ‘14	
Deli Business & Perishable	24,000	Aug/Sep ’14, Dec/Jan ‘ 14	Jul - Nov ‘ 14
School Nutrition	24,000	Aug ’14, Dec ‘14	
CN Executive Update	18,624	August ’14	Aug ’14 – Oct ‘14
Meeting Place	30,005	October ’14	Sept ’14, Nov ‘14

5) Website: A protein specific website was developed within the “Sunsweet Ingredients” master site. The protein site includes striking graphics, product information, usage guidelines, product specifications, and research. The Sunsweet Ingredients website averages 300 unique visits per month.

The project only benefitted the prune industry.

R&D Consulting and J.M. Degen and Associates conducted direct outreach to industry members. These two groups also provided technical support and attended all trade shows.

CropSource International served as project managers, and coordinated all trade show events, developed promotional materials, ad messaging and placements, and oversaw direct outreach activities.

Augustine Ideas produced the web site as well as developed and placed the trade ads.

Goals and Outcomes Achieved

The key measurable outcome was to increase returns to California prune growers. The project goal was to net an additional $4.3 million dollar return to Sunsweet’s 307 grower members over three years. Sales of products promoted for use in chicken and other proteins have amounted to $1,902,528 in the two years from November 1, 2012 through October 31, 2014. There are now thirty active customers ordering these products. The business has grown at a 30% rate, and project staff expect that to continue in the future. By November 1, 2015, the three year mark from initiation of the project, staff project that total sales of relevant SKUs will reach $3.2 million from project start.

Another goal was to achieve market penetration of 10% of the poultry moisture retention market. Although this goal has not yet been reached in terms of actual sales volume, staff are confident that at least 10% of poultry and other protein processors are aware of the potential benefits of using plum products as a replacement for phosphate. Staff have had multiple contacts with both Tyson and Cargill and have provided them with numerous samples. These companies alone account for more than 10% of the US poultry business.

Awareness of prune products as a substitute for phosphates has primarily been driven by the trade show and by trade advertising activities. In the two years staff have conducted these activities they have obtained 100 protein related leads from trade shows and 25 from trade advertising. “Leads” refers to companies that have specifically asked for more information and/or samples with which to do testing. These leads do not include companies that have become aware of prunes for protein applications but have not yet specifically asked for more details or samples. Staff believe that throughout the protein industry the awareness of the prune option for moisture retention is quite high and that as success stories emerge more and more companies will move from the “awareness only” category to true “leads”.
Another activity that has increased awareness is the construction and maintenance of a first rate web site. The www.sunsweetingredients.com website received 569 visits (487 new visitors) in September 2014. Of these visits at least 100 viewed the pages related to the phosphate replacement.

The outcome measures were not long term. However, this project will result in substantial long-term benefits to Sunsweet growers and the greater California prune industry. The amount of sales made to date is just a small fraction of the long term potential in this category. All food manufacturers worldwide are working to develop healthier products and eliminate artificial ingredients and chemicals from their product lines. The amount of interest staff have been able to gain in just two short years is highly encouraging. Moreover, because of the large number of samples staff have sent to potential customers and the increasing amount of technical questions they are asked, staff know that there is quite a lot of experimentation being made with the products. This project allowed Sunsweet to lay a solid foundation for exponential growth in this protein category in the near term and steady growth in the long term as the marketing effort expands to overseas markets. The major limiting factor on sales growth will be supply, but this pressure on supply will allow returns to the growers to increase dramatically.

Comparison of actual accomplishments:

Goal one – Increase returns to Sunsweet Growers in the amount of $4.3 million over three years.
Actual result: In the 2014 Fiscal Year, Sunsweet return to growers increased by $27 million, a 28% growth. The protein initiative contributed to this success, by generating incremental revenue, projected at $3.2 million for year 3.

Goal two - Grow top line sales $16 million over three years.
Actual result: Top line sales were $1.9 million for two years, and $3.2 million projected for three years.

Goal three – Capture 10% of the poultry moisture retention market.
Actual result: less than 1% (not measurable)

Goal four – Attend five tradeshows
Actual result: seven tradeshows attended

Goal five - Increase web traffic from zero to five hundred
Actual result: 569 visitors to website in September 2014

Goal six - Create awareness
150 trade leads developed from tradeshows, trade advertising, and website

Baseline data that has been gathered and progress toward achieving targets:

1. Actual sales of protein related prune products from November 1, 2013 until October 31, 2014 amounted to $1.9 million. The number of customers ordering is 30.
2. 150 number of trade leads have been obtained in only two years
3. Website realized 10,000 visitors since inception
4. Actual products that use plum as a replacement for chemicals can be found today in:
    a. 83 Wegman's supermarkets (6 items)
    b. 1,700 Panda Express restaurants
    c. All public schools in Los Angeles school district
    d. Public schools in Cincinnati, Fairfax VA, and Philadelphia

The first major successful outcome was proof of concept. Before the project was initiated plum products had been tested for phosphate replacement in a university setting, but the commercial validity of the concept could not be known until the project team actually engaged the target market and work to convert concept to actual sales. Staff have realized enough success to feel confident of the validity of the project, and it is this "proof of concept" that allows Sunsweet to justify making additional strong efforts and investment to realize the very significant potential of this market.

The second major accomplishment was the high awareness staff have created. The concept that prune products could serve as a replacement for phosphates and other chemicals in protein processing was highly novel two years ago; awareness was near zero. The first efforts at trade shows were met with skepticism, but persistence at the trade shows coupled with steady trade advertising and constant out-reach by a team of professionals have created a high level of awareness among protein processors that will allow for steady sales growth over many years.

The third major accomplishment is the development of success stories. Nothing motivates action by potential customers as much as seeing positive results from other industry participants. Staff are particularly pleased by the results of sales efforts to help provide clean label proteins for the school lunch program. The Jennie-O turkey company replaced phosphates with plum products from a core school food service item, turkey burgers. This product now has a "clean label" and is accepted by the Los Angeles School District as well as several others. Another school provider, JTM of Cincinnati, reformulated over 20 items, including their mainstay beef patty, with plum products to remove undesired chemicals and allergen ingredients. The school success stories are important in two ways. The first is that schools are proud of the steps they are taking to provide healthier meals to children and they allow Sunsweet to use their success with plum enhanced products to promote business. Moreover, as demand for such items at the school level increases, important suppliers such as Tyson will need to listen to the food directors and do more experimentation with plum formulations. The second important benefit of this success story is that it helps drive the main message for replacing artificial ingredients for plum products – health. Healthier eating and clean label food products are the most important topics in the food trade worldwide. The school success story allows Sunsweet to stake a claim to being an important part of the solution.

Beneficiaries

Groups that benefited from this project:

1. The 307 grower members of Sunsweet Growers obtained additional sales of $3.2 million.
2. The entire California prune industry benefits by the establishment of a potentially very large new sales channel. As the demand builds for this new market the industry will be able to lift prices thereby ensuring its long-term prosperity.
3. Consumers of Wegman's supermarkets, Panda Express restaurants, Perkins coffee shops, among others, are consuming healthier products.
4. School children in Los Angeles, Cincinnati, Virginia, and Philadelphia are now consuming clean label turkey and beef patties.

Number of beneficiaries affected by this project:

1. 307 members of the Sunsweet Growers prune cooperative
2. An estimated 400 California prune growers that do not belong to Sunsweet
3. An estimated 2000 employees of the California prune industry
4. 750,000 children in the Los Angeles school district
5. Long-run, approximately 30 million U.S. school children that participate in the school lunch program (by consuming fewer artificial ingredients and chemicals)

Lessons Learned

A major lesson learned is that the processing of proteins is highly complex and the industry moves very slowly. Each processing plant will use different equipment and different grades of raw protein. It is difficult to define usage guidelines for a new ingredient such as plum for such a varied range of circumstances. Moreover, while staff had a highly qualified research chef as part of the team, other team members often floundered when confronted by technical questions.

At the same time, changing any process in a protein facility requires considerable R&D, which is quite expensive. It is not enough to obtain the general interest of a potential customer; staff needed to move them to a level of interest that would prompt them to invest in the R&D and process development work.

Finally, staff learned that there is little innovation within the industry except when it comes to cost reductions. More than that, there is out right resistance to change unless it is demanded from end users such as restaurant chains, retailers, or school food service.

In sum, even with a proven product that provides many solutions, the sales challenge is quite significant, and tougher than expected.

At the same time, staff learned that the demand for healthier products is almost deafening, and that if there is a product that can help manufactured food be healthier there is a substantial opportunity. R&D staffs at major chain restaurants, for example, are constantly being tasked with reformulating products to reduce fat, salt, and sugar. There is a desire within major food manufacturers to become part of the health solution rather than the chief cause of health problems. Having said that, phosphate replacement is not yet high on the list of problems to solve because consumers have a low awareness of phosphates, and until recently it has not been recognized as having potential health implications. However, new studies are coming out that indicate there are actually health problems with over consumption of phosphates and that the amount consumed by the US public far exceeds recommended levels. The emergence of these new studies seems to be creating more interest to reduce phosphates, as well as clean up labels in general.

While staff discovered that the sales effort is more challenging than expected, they have also learned that the market potential is much bigger than originally estimated and that the health benefits plum can provide to consumers of processed proteins are highly important.

Staff had a very interesting learning experience from the JTM Company out of Cincinnati. JTM tried plum fiber as a replacement for artificial caramel coloring in their pre-cooked beef patty that they supply to schools nationwide. JTM discovered that the fiber worked great as a replacement for caramel color, but in addition they found that due to its moisture retention capability they could de-glaze the patties more thereby reducing fat and that the school children preferred the new patty even though it had lower fat content. Finally, they also found that it could reduce cost. This was a four-way win – better flavor, removal of artificial ingredients, lower fat, and lower cost. This experience has pointed Sunsweet to many opportunities that project staff did not know existed.

Along these same lines, a regional east coast sausage manufacturer found they could reduce sodium and fat from several of their sausage items by using 3% prune puree, an ingredient Sunsweet sells to bakeries but did not plan to offer to protein manufacturers. Not only did the use of plum provide for a clean label and a better nutrition panel, it also reduced cost by $0.22 per pound.

The goals not achieved are the total targeted return for the 307 growers of Sunsweet and the top-line sales targets. Staff are highly confident these goals can be met within the near future. The main reason for not reaching these targets within the project dates is the underestimation of the sale challenge and the long lead-time for R&D and process changes within the protein industry.

To anyone working on a similar project, staff would recommend being very conservative on initial sales estimates and to be highly persistent in the sales effort. Staff found the number of trade shows, trade ads, and direct outreach efforts to be just about right. The one thing staff calculated incorrectly is the lead time for potential customers to work through R&D.

Additional Information

Attachment: Marketing materials and article

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 15	**Project Title:** Export Development of California Specialty Crops	
Grant Recipient: Center for International Trade Development, State Center Community College District	**Grant Agreement No.:** SCB12015	**Date Submitted:** December 2015
Recipient Contact: Alicia Rios	**Telephone:** 559-324-6401	**Email:** alicia.rios@scccd.edu

Project Summary

The future of California specialty crop producers depends largely on a well-trained workforce that can compete internationally. 25-30% of California's agriculture output is sold overseas - in some cases (like almonds) roughly 70% of the crop is exported. With global populations and incomes rising, exports become even more important to California specialty crops. Without the "human capital" to take advantage of these opportunities, California specialty crops will suffer internationally.

In California, there is no other comprehensive training program to develop new Ag exporters. This project will increase the supply of well-trained personnel who are able to market, sell, and ship high-value California specialty crops internationally, through statewide training that focuses on the specific requirements of specialty crops: maintaining freshness, quality, cold-chain, phytosanitary regulations, etc.

This project builds on the 2009 Specialty Crop Block Grant Project 23: *Export Training for Specialty Crops* that provided certified export training. Under this project, Center for International Trade Development (CITD) built upon the previous project by using the knowledge and experience gained to improve and update the course curriculum; expand the level of awareness and participation of new specialty crop companies; expand training through the internet with additional resources and video modules; enhance the basic training with specific "modules" for tradeshow preparation and "trouble-shooting" consultations; and offer trainees practical experience in dealing with foreign buyers, both through Inbound and Outbound trade missions. Another focus was the increase in the number of trainees accessing Branded Program funding to support their export promotions. Also, because of the experience gained through the initial project, CITD projected a 20% increase in the number of companies trained, even with a corresponding 20% decrease in the budget.

Project Approach

Over the term of this project, CITD had a goal of training 120 qualified specialty crop companies, providing another 50 companies with technical assistance/counseling, provide 24 companies with opportunity to participate in the Branded Program, and increase overall export sales of participants by 6 million dollars.

To achieve the export training goals, CITD partnered with over 30 organizations (each with a high number of specialty crop company members/clients) to assist in its recruitment efforts for the CalAgX program. CITD marketing activities included cold calling specialty crop companies across California, e-blasts to our database of over 5,000 companies, partners disseminating recruitment pieces throughout their respective networks, and exhibiting/attending trade shows to meet face-to-face with potential candidates. CITD estimate it reached out to over 30,000 potential candidates.

CITD held the CalAgX training program during each program year in 3 locations (except for year 2), and had 92 companies register and 142 participates. CITD added a training location to a more rural community during year 2, where initial interest was high and a significant number of specialty crop companies where located, but recruitment presented new challenges. Most small companies had minimal staff and were unable to send someone through training, or they sold their products to a packer/consolidator, and chose not to participate. The project team's recommendation would be to host training in 3 static strategic areas so that companies will know where it will be each year and plan accordingly to attend, and leverage more resources and services to add value and better equip participants for export success.

CITD also provided 100+ companies with client counseling/technical assistance via development of customized market assessments, over-the-phone/email request specific assistance, and consultation during trade missions. CITD found that most companies need assistance but cannot express their challenge. CITD learned the best way to identify a company's need is one on one, during a trade meeting asking a simple question, "How is your company doing exporting this year?" Companies immediately discussed their issues or barriers, and CITD provided direction and solutions.

During the course of this project, CITD was very successful in garnering interest in the Branded Program from both new and veteran exporters. By incorporating the Branded Program into the curriculum for the marketing session, CalAgX participants were able to ease into the program with a better understanding and without the fear that most newcomers have had in the past. CITD also hosted specific Branded Program workshops as well, and had over 54 companies participate that can be directly attributed to this project.

CITD was able to leverage resources and has offered 9 inbound and 1 outbound trade missions to California specialty crop companies to promote and sell qualified products to foreign distributors. Reported new export sales were in excess of $6,479,598 with another $12,293,000 projected by exporters over the upcoming 12 months following each respective mission date.

This project only benefitted specialty crop companies and CITD ensured this through a registration screening process whereby only qualified specialty crop companies were allowed to participate in project activities. CalAgX partners primarily assisted in statewide recruitment of potential participants (estimated 2,500 potential participants contacted each program year) and in several cases, hosting CalAgX training sessions. Each partner has hundreds of specialty crop members/clients that it can instantly reach out to creating a outreach multiplier effect. Partners included the California Department of Food & Agriculture, California Centers for International Trade Development (9 Centers), California Farm Bureau Federation (County Farm Bureaus), Western Growers Association, California Certified Organic Farmers, Specialty Crop Trade Council, Dried Fruit Association, Ports of Los Angeles and Oakland, Western United States Agricultural Trade Association, USDA Foreign Agricultural Service, and many more regional economic development associations.

Goals and Outcomes Achieved

Some of the activities that were completed in order to achieve the performance goals and measurable outcome as planned in the project proposal are below:

Export Training:

- Year 1 CalAgX: The 6 session export training series for California specialty crop companies was held concurrently in three locations (Sacramento, Clovis and Corona, California) starting March 5, 2013 and ending May 16, 2013.
- Year 2 CalAgX: The 6 session export training series for California specialty crop companies was held concurrently in two locations (Sacramento and Clovis, California) starting August 5, 2014 and ending September 24, 2014.
- Year 3 CalAgX: The 6 session export training series for California specialty crop companies was held concurrently in three locations (Sacramento, Clovis and Salinas, California) starting April 28, 2015 and ending June 4, 2015.

Branded Program:

- Year 1 Branded Program Workshops: Branded Program workshops were facilitated in Los Angeles, Clovis and San Francisco, California on August 19-21, 2013.
- Year 3 Branded Program Workshops: Branded Program workshops was facilitated in Sacramento, California on December 9, 2014.
- Additionally, the Branded program was incorporated into the Marketing session curriculum of the CalAgX training program and presented all 3 years.

Trade Mission Activities:

- Year 1: Mexico/Central America “Fresh Produce” Inbound Mission on July 8-9, 2013 in Central Valley, California.
- Year 1: Southeast Asia Fresh Produce Buying Mission (including site visits) that took place in Fresno and Monterey on July 25 – 29, 2013.
- Year 1: China Dried Fruit & Nut Inbound Mission on Aug 12-16, 2013 in Central Valley, CA.
- Year 1: Taiwan Fresh Produce Mission on August 21-23, 2013 in Central Valley, CA.
- Year 2: ATO Shanghai Nut Buyer Inbound Mission on June 11-14, 2014 in Modesto and Fresno, CA.
- Year 2: Central America/Mexico Inbound Produce Mission on July 14-16, 2014 in Central Valley, CA.
- Year 2: Fresno Food Expo on July 24, 2014 in Fresno, CA.
- Year 2: ASEAN Fresh Retail Inbound Mission on August 20-22, 2014 in Fresno, CA.
- Year 3: European Dried Fruit and Nut Inbound Mission on December 9-12, 2014 in Sacramento, Modesto and Fresno, CA.
- Year 3: Shanghai Nut Buyer Inbound Mission on Mar 3-6, 2015 in Modesto and Fresno, CA.
- Year 3: CA Grown Specialty Crop Trade Promotion to Hong Kong and China on May 28, 2015 – June 6, 2015.

Long-term outcome measures include export sales from project participants. CITD documented both immediate and follow-up export sales that can be directly attributed to participation in this project. Through previous experience, CITD knows that some new distributor relationships can take up to 1-2 years to develop.

CITD does not track long-term distributor/supplier relationship whereby participants will continue to develop export sales with same distributor met through this project for many years to come.

Please see the comparison of project goals versus actual accomplishments, and the completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets below:

Goal 1 - Recruit and train a minimum of 120 qualified California specialty crop companies (growers, processors, or marketers) on how to export the product to foreign markets.

GOALS	Baseline	Year 1	Year 2	Year 3
Target	31	40	40	40
Actual		37	25	30

Goal 2 - Provide Technical Assistance/Counseling to Specialty Crop Companies.

GOALS	Baseline	Year 1	Year 2	Year 3
Target	15	20	20	10
Actual		13	14	37

Goal 3 - Increase the number of companies applying for Market Access Program (MAP) Branded Funds.

GOALS	Baseline	Year 1	Year 2	Year 3
Target	4	6	8	10
Actual		36	0	18

Goal 4: Increase overall export sales of participants by $6 million over 3 years.

GOALS	Baseline (Cumulative)	Year 1	Year 2	Year 3
Target	$4 million	$1.5 million	$2 million	$2.5 million
Direct Sales		$263,000	$1,534,558	$4,682,040
Projected Additional Sales		$2,083,000	Data incomplete	$10,210,000

Throughout this project, participants are not only highly trained to export specialty crop products, but are given opportunities and resources to thrive in the export sales industry. From the 142 CalAgX participants, 60% of the participants were sales personnel from their organization, and 40% worked on the logistical support side of the business. 90% of all the companies that have participated in training, moved forward with their export development plans, participated in trade development activities, utilized the Branded Program, and inquired about foreign distributors on their own. This project's yearly export sales increase clearly demonstrates how export knowledge translates to exponential sales growth over time. CITD documented over $6,479,598 in direct sales and participants also projected that another $12,293,000 will be developed over time through the business relationships established through this project.

Beneficiaries

The eligibility criteria of this program favored those companies that are "new-to- export" that is, those that either currently do not export, or have limited export experience with the goal of turning them into "exporters". Thus, this project will bring new sales to the California specialty crop industry through the efforts of the "new-to-export" companies trained and participating in this project, as sales expand into new markets (rather than merely gaining market share at the expense of other California producers). Indirectly, the project benefits a much larger share of California's specialty crop industries, as new markets develop overseas, increased overall demand will raise the general price received by all producers.

The training was available to all California specialty crops companies. Using the success of the initial Specialty Crop Training program as a baseline indicator, expected outcome for these participants was the generation of $6.0 million in new export sales of specialty crops over the term of the project which is a 15 times greater than the initial investment for the specialty crop industry and California. CITD exceeded this goal by nearly a half a million dollars. As reported by the USDA, for every $1 billion in agricultural export sales, 8,000 jobs are created and/or sustained, and an additional $1.4 billion in economic activity is generated. According to this model and the CITD's exceeding its target goal of $6.0 million in new export sales, over 1,300 jobs were created and/or sustained with a total economic impact of $14.4 million.

Lessons Learned

When it comes to recruitment of participants for training and/or trade missions, partnering with organizations that have a vested interest in target group increases success. CITD measures a lot of its success by export sales generated by participants. Most companies that participated in the export training programs do not immediately produce export sales results, with exceptions. The participants generally take 1-2 years to implement and export plan and generate tangible success, therefore projects goals should be set according to that timeline in the future.

Unexpected outcomes included the type of participants that registered for the CalAgX training (sales persons vs. logistical support personnel) and the number of participants wanting to utilize federal resources. The comprehensiveness of the 6 modules of the CalAgX training inspired more companies to send more support personnel which strengthened their overall export teams. Additionally, CITD changed the way it marketed the Branded Program by bringing Western United States Agricultural Trade Association representatives to California for more group and one-on-one meetings. This personal contact with the administration team for the program added to its validity and garnered significantly more interest.

Two things highly necessary to consider when recruiting companies, timing of the classes (busy season or slow season), and location. It's not possible to accommodate all specialty crop producers due to the variety of their seasons. CITD adjusted the schedule to fall for year 2 to incorporate more companies that could not attend in spring time, and unfortunately, registration was even lower than before. The project team recommends having a static time and location for training classes. Even though CITD had over 142 participants, there were only 92 unique specialty crop companies participating due to schedule conflicts.

Additional Information

Information and updates on the program can be found at: http://fresnocitd.org/export-programs/export-training/calagx. Additional published information can be found under Attachment #1.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
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<table>
<tr><td>USDA Project No.:
16</td><td colspan="2">Project Title: Promoting Healthy Fruits to Safeguard California's Peach and Apricot Industries</td></tr>
<tr><td>Grant Recipient:
California Cling Peach Board</td><td>Grant Agreement No.:
SCB12016</td><td>Date Submitted:
December 2015</td></tr>
<tr><td>Recipient Contact:
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jdallen@tabcomp.com</td></tr>
</table>

Project Summary

The California Cling Peach Board (CCPB) sought grant assistance to spotlight the findings of the Oregon State University (OSU) canned peach nutritional research via pilot marketing/outreach campaigns, and an in-store promotion with a California retailer (Lucky/Save-Mart, etc.), and social media to highlight the nutritional benefits of canned peaches and the importance of buying domestic California products. The immediate objective is a 5 -10% increase in sales of California canned peaches and apricots/fruit cups at the store during the promotion period (Oct 2013-Mar 2014).

US canned peach and apricot sales have long been declining, dropping 16% over the last 10 years. As a result, tree pull-outs are increasing and 769 acres of California cling peaches were removed in 2011 alone, about 3.5% of total bearing acres. These trends are a product of growing imports that make up about 18% of U.S. canned peach sales and misconceptions about the nutritional value and safety of canned fruit. "Fresh is best" campaigns have hurt the canned fruit industry which, due to smaller budgets, has struggled to effectively promote the nutritional benefits of canned fruits. Fresh fruit has to be imported off-season, taking further sales from California producers who could be selling more canned California peaches and apricots for off-season consumption. If these trends are not reversed quickly, peach and apricot farmers in California will continue to lose processing contracts. Fortunately, a major new study by Oregon State University was published in spring 2012 shows that there are benefits to choosing canned fruit over fresh fruit, including higher levels of Vitamin C, Vitamin A, foliates, and antioxidants. Timeliness was essential as these industries needed to take this research, develop "consumer-approved" positioning, and test it at the retail level to see if sales of canned peaches and apricots could be increased.

This project does not build on a previously funded SCBGP project.

Project Approach

--Project staff reviewed case studies & scientific research related to the nutritional benefits of canned peaches and apricots. Staff looked at studies conducted at UC Davis including the work of Diane Barret, specifically "Maximizing the Nutritional Value of Fruits & Vegetables" http://www.fruitandvegetable.ucdavis.edu/files/197179.pdf and this additional study: http://ucce.ucdavis.edu/files/datastore/234-779.pdf.

--Conduct 10-person focus group: Staff conducted 3 focus groups made up of 8 individuals. Staff were able to test different nutrition statements and positioning for canned peaches and apricots and get real-time feedback from consumers. This feedback informed the concepts that were then created for the national survey

--Determine retail partner for in-store promotion: Project staff looked at various partners and eliminated some because of their use of in-store rating systems or they did not appear nimble enough to work with project staff

(3 stores over a 6-week period). SaveMart was chosen because of their flexibility, their connection to California, and their ability to provide project staff with the sales tracking that was required for the project

--Conduct 100 national online surveys to gain an objective view on how consumers view:

- Canned peaches/apricots
- The importance of nutritional claims made
- The importance of buying domestic vs. imports
- Food safety of domestic canned fruit vs. imports from China

--The response to the survey far exceeded expectations with over 2,700 respondents (2,600 more than anticipated) with detailed feedback on 5 different positionings for canned peaches and apricots.

--Evaluated the best communications platforms (TV, print, radio, social media, etc.) with the SaveMart team and with processors. It was agreed that while traditional advertising might bump up sales in the three store locations (Clovis, Sacramento & San Francisco), project staff were told that such a spend would not be later replicated by processors (whom would need to adopt this project long term) and would only skew the test results. Hence the ad spend was dropped and replaced by social media and an online contest to "Win Peaches for a Year." (Not grant funded)

--Project staff worked closely with SaveMart on materials for the in-store promotions to make sure that they were appropriate and turnkey for the SaveMart team: Interactions, and to ensure that they could be replicated by processors. Items included customized shippers, stand alone and laminate signage, nutrition & recipe handouts, as well as "I Heart Peaches/Apricots" t-shirts for the SaveMart staff.

--Project staff also conducted a second online survey (to 100 hand-selected participants from the 4 national markets) to verify positioning. "The 100% Healthy Snack" was deemed the winning positioning and used throughout all of the in-store promotional materials.

--Cognise Consulting produced a consumer attitude summary via a power point so that Echo and Cognise could easily make presentations to processors and retailers. Attached is the "Canned Fruit Focus Groups Executive Summary" for an overview of the findings of the focus groups conducted in Sacramento, California.

--Echo Communication created specialized snacking Tweets and Facebook posts promoting the SaveMart/Lucky program, which drove traffic to www.calclingpeach.com, where participants could take a look at a list of their favorite peach snacks and then vote for one or post it on Facebook.

--Echo Communications, in collaboration with processors & SaveMart, developed a retail test pilot program, including the production of collateral pieces, store displays, handouts, posters and infographics. Newspaper and in/store print ads were not produced as project staff received feedback from processors that this was a component that they could not easily replicate if they were to adopt the program in the future. Hence they wanted a minimum spend on collateral/supporting components in order to best test the impact of the nutritional messaging without the influence of an advertising spend that they would not later adopt.

--The in-store program ran January 17-18 (3 stores), February 7-8 (3 stores), February 20th (1 store) & February 27th (2 stores). According to SaveMart, staffing issues and the flu/cold season prevented all stores from participating later in February (the grant was not charged for the 3 missed sampling programs). Ultimately the program was redesigned (per SaveMart's guidance) to use 3 stores (instead of 1), but during a shorter period (6 weeks instead of months)

--SaveMart intended to provide Echo with in store magazine and blogger support for this sampling program, but due to the many staffing changes with the SaveMart team, this was not possible.

--Echo procured shippers from Pacific Coast Producers (PCP), which were then customized to meet the specific demands of the program. Echo worked with the SaveMart team to develop a sampling manual (project staff provided the copy; SaveMart produced internally). Staff also created a handout promoting California canned peaches and apricots (see attached for before and after photo of shipper).

--In order to make the program as turnkey as possible for processors, Echo bumped up social media efforts and sent out an e-blast promoting the Top 25 Ways to enjoy canned peaches.

California peaches and apricots are the only commodity that benefitted from this project.

Project partner contributions include:
--CCPB/Monfort Management/JD Allen & John Gilstrap managed the project every step of the way and also served as "boots on the ground" in the Clovis area during the in-store promotions campaign. (This greatly assisted Echo Communications in monitoring the implementation of the campaign.)

--The Apricot Producers of California/Bill Ferriera worked in tandem with Echo and the CCPB team on all elements including attending the focus groups in Sacramento

--Del Monte Foods provided insight into how to build the in-store campaign

--PCP provided "generic" shippers for Echo to customize as a limited print run from a shipper manufacturer was not possible

--All processors shared the "100% Healthy Snack" campaign to their social media teams for additional exposure

Goals and Outcomes Achieved

Activities completed to achieve performance goals include:
--Qualitative research: 3 focus groups in Sacramento
--Quantitative research: 2 national online surveys
--Website updates & social media campaign
--In-store promotions program with SaveMart (Clovis & Sacramento) & Lucky (San Francisco)

Actual accomplishments:
--The first goal of the project was to raise public awareness of the nutritional benefits of canned California peaches and apricots. This was to be measured via the Media Relations Ratings Points system, however, that

data would have been tied to print advertising and print media coverage. As stated above, project staff had to convert to a social media and web-based campaign but were still able to reach over 1 million positive impressions.

In store: 5,400
Website: 22,960
Facebook: 7,320
Twitter: 1.02 MM
TOTAL: 1,035,690 positive impressions

--The second goal was to generate a 5 -10% increase in sales of California canned peaches and apricots/fruit cups at the store during the promotion period. The in-store promotion campaign (sampling and tested messaging), supported by social media, in-store print handouts, and a Facebook contest, proved to increase the sales of California canned peaches and apricots, as well as California peach and apricot cups/bowls. Based on reports from SaveMart/Lucky, sales increased, on average, 37.5% over the same period previous year; the average promotion period % lift for the 4 UPCs was 72.25%

Here is the breakout of the data (actual sales numbers attached):

January 17-18 Promotion period:
- Year Over Year (YoY)/SaveMart & Lucky lift: 141% increase (over same 4 week period previous year)
- Incremental sales week of the event: 141% up; dollars up 253%
- YoY SaveMart only lift: 170%; incremental sales week of event 170%; dollars up 282%
- YoY Lucky only lift: 88%; incremental sales 88%; dollars up 199%
- Promotion period %lift for 4 UPCs: 117% during promotion period (4 week average)
- Non event stores, sales up 1% during same period (4 week average)

February 7-8 Promotion period:
- Year Over Year (YoY)/SaveMart & Lucky lift: 25% increase (over same 4 week period previous year)
- Incremental sales week of the event: 25% up; dollars up 95%
- YoY SaveMart only lift: 22%; incremental sales week of event 22%; dollars up 87%
- YoY Lucky only lift: 49%; incremental sales 49%; dollars up 152%
- Promotion period %lift for 4 UPCs: 90% during promotion period (4 week average)
- Non event stores, sales declined 9% during same period (4 week average)

February 20th Promotion period:
- Year Over Year (YoY)/Only one store reporting: 20% decrease (over same 4 weeks previous year)
- Incremental sales week of the event: 20% down; dollars up 7%
- Promotion period %lift for 4 UPCs: 29% increase during promotion period (4 week average)
- Non event stores, sales declined 8% during same period (4 week average)

February 27th Promotion period:
- Year Over Year (YoY)/Only two stores reporting (SaveMart & Lucky): 4% increase (over same 4 week period previous year)
- Incremental sales week of the event: 4% up; dollars up 36%

Promotion period %lift for 4 UPCs: 53% during promotion period (4 week average)
Non event stores, sales increased 14% during same period (4 week average)

-- The third goal of the project was to slow the decline of cling peach and apricot acreage. Although the acreage of cling peaches does continue to decline, the rate of decline seems to have slowed somewhat.

2012-2013: 7% decline
2013-2014: 6.13% decline
2014-2015: 5.5% decline

2012: Peach 22,800 acres
Now 18,800 + 2,800 (new plantings, non-bearing acres)

For apricots, the acreage has remained relatively flat, with a 3% decline over the last three years, but with new plantings scheduled.

2012: Apricot 10,500 acres
Now: 10,150 with new plantings scheduled

The reason for the decline has been the explosion of nut crops. Walnut and almond crops can be mechanically harvested and sell for a significantly higher price per ton; thus making those crops much more attractive to cling peach growers. Project staff do know from peach growers at a recent CCPB meeting that growers are planning more new plantings this year as the nut industry is peaking and the price per ton of peaches did increase this year. Additionally, the demand for peaches has increased and there is currently a shortage in the marketplace. Lastly, both the peach and apricot industries have had to deal with a historic drought.

Beneficiaries

Groups that benefited from this project include:
--California Cling Peach Growers
--California Apricot Growers
--Consumers
--Del Monte Foods (processor)
--Pacific Coast Producers (processor)
--Seneca Foods (processor)
--California Canning Peach Association (bargaining association)
--The California Cling Peach Board's Domestic Public Relations Program (marketing order; executes messaging aimed at increasing consumption of California Cling Peaches)
--The Apricot Producers of California (conducts bargaining & marketing activities on behalf of the apricot growers of California)

The primary beneficiaries are California's 400+ family-owned peach growers and the 150+ apricot growers and their farms and the state's struggling fruit canning industry.

Lessons Learned

Timelines served as important guideposts throughout the project, but were adjusted based on the availability of a retail partner to execute the in-store nutrition education/sampling promotion program. Because project staff were only working with 3 store locations and working around non-peak times (fresh season, Halloween, Thanksgiving, Christmas, etc.), staff had to be flexible and thus the project took longer to complete than originally planned.

Communication and coordination at the retail stores is essential to successfully execute an in-store promotion. What project staff discovered was that a lack of close communication between the sampling staff and the store manager created problems. After the 1st morning of sampling, project staff found that mandarin oranges and pineapple tidbits had been stocked instead of apricot and peach cups. As a result, project staff monitored the upcoming samplings directly, via onsite visits and or direct communication with store managers and, at times, hand-delivered materials. Project staff believes had the program not been closely managed and coordinated with the store level, the program would have only been marginally successful.

Additional Information

1. Fruit Focus Groups Executive Summary
2. Various photos from project
3. Actual sales numbers
4. Infographic SaveMart
5. Winning positioning

USDA Project No.: 17	**Project Title:** Economic Impact analysis of the removal of the starch-iodine requirement for Granny Smith apples	
Grant Recipient: California Apple Commission	**Grant Agreement No.:** SCB12017	**Date Submitted:** December 2014
Recipient Contact: Alexander Ott	**Telephone:** 559-225-3000	**Email:** aott@calapple.org

Project Summary
In June, 2011, at the request of the California Apple Commission (CAC), the State of California removed the Granny Smith (GS) Maturity Standard. This standard had been in place since 1992. The standard stated that California GS growers were not allowed to harvest the apple until the apple reached a 2.5 Starch-Iodine maturity reading and was released by the specific county inspector. This 2.5 number became very subjective and led to some growers becoming increasingly irritated with the process. By comparing previous GS data to 2011 and 2012 seasons, this grant will quantify the amount of revenue whether it was positive or negative that was earned due to the removal of the GS standard. The main questions that this grant will answer are: Did the removal of the standard have positive or negative impact on the California GS market? In addition, if the removal of the standard was negative should it be reinstated and at what Starch-Iodine level? Timing of the GS harvest is imperative because if the California growers are too early they run into competition with the Southern Hemisphere. If the California GS harvest is late, products from other states flood the market. Determining the proper Starch-iodine level and comparing that with marketability and harvest timing issues will give the California Apple Commission the appropriate California GS harvest condition

This project built upon 2010 SCBGP project 9, which in part researched what maturity consumers preferred in the GS variety, and taste tests confirmed a valid GS maturity number. That number can be applied to a new standard if the industry determines it needs one once the Economic Impact study is complete. This new standard will determine the release date and maturity of all GS in California. This project was imperative in deciding if the standard helped make the GS industry profitable or did the standard hinder it. This project also researched an objective way of measuring the starch in GS apples. One method that proved extremely accurate was to make the Granny Smith apple into a slurry mixture infused with an Iodine solution. This method provides and accurate, objective, and quantifiable measurement that can be applied as a standard unilaterally throughout the California Apple industry.

Project Approach
The objectives for this project were to determine the proper starch-iodine level and compare the marketability and harvest timing issues to determine the appropriate California GS harvest conditions. To accomplish these objectives, the following activities were performed: 1) a consultant firm was hired to perform the required data collection, research, and analysis of Granny Smith starch-iodine standardization; 2) presented the research results to the Board of Directors on June 31, 2013; 3) disseminate the research results to the California apple industry by mailing the research report with the CAC Annual Report; 4) extended the project duration in order to review the initial 2013-2014 Granny Smith season with the handlers in regards to the impact of the removal of the Standardization.

The final results of the research proved to be extremely useful. The research conducted by Dan Block & Associates (entire report is attached) demonstrated that the California apple industry was hindering itself by enforcing the California Granny Smith Standard. Three key findings during the study were:

1) Results of the econometric model presented in this study indicate that, for nine of 13 crop years, Granny Smith sellers would have obtained additional revenues in the absence of a maturity standard.
2) Model results show that, from 1998 to 2010, the California Granny Smith maturity standard could have delayed the start of shipments by up to five weeks in some years.
3) The effect of the Granny Smith maturity standard on California industry revenues is estimated at a negative $18.7 million over the 13 years for which data were available. With over 18.4 million boxes of Granny Smiths shipped between the 1998 and 2010 seasons, this figure corresponds to a loss of approximately $1.01 per box on average over the 13-year period.

The final results of the research demonstrated to the CAC Board of Directors that the California Granny Smith Standard was not viable/profitable to the California apple industry. Because of this information, the CAC Board of Directors voted to continue the repeal and suspension of the G.S. Standard.

Goals and Outcomes Achieved

The major objective of this project was to produce quantifiable data to support the elimination or reinstatement of the GS standard. The creation of a historical database built on the statistical analysis of GS pricing and shipments before, during, and after the imposition of the GS standard, and pricing data from USDA, CDFA, and California apple packing facilities collected and analyzed determined a baseline when comparing the Granny Smith seasons. After evaluating all relevant information, a complete report narrative describing the background of the issue, the CAC's involvement in removing the restriction, and a detailed explanation of the methodologies used to examine the economic impacts was distributed to the CAC Board of Directors. The CAC Board of Directors used the research to make the determination to maintain the elimination of the standard or reinstate it. After evaluating the report, the CAC Board of Directors distributed the non-confidential information to the industry with the decision on the standard. This was completed within the timeframe of the grant.

Beneficiaries

Economically, this grant impacted 89 growers and 8 packing facilities of apples in California which account for roughly 18,000 acres throughout the state. The value of the GS variety in California fluctuates but is worth approximately $42 million dollars, and is distinguished throughout the world for having superior taste and high quality color. This project enabled the industry to determine if a standard positively or negatively affected the GS industry and whether or not a standard needed to be implemented. Harvest timing issues affect the California Granny Smith apple crop severely. Having an objective testing method and reasonable maturity standard allowed for growers to capture the market at a profitable point without diminishing the quality Granny Smith apple that California is known for. Before the grant was initiated, the California Apple Commission held several discussions with multiple growers to discern the effect of the removal of the standard. The results were varied; some growers felt that the removal of the standard affected quality and therefore price while others suggested that the removal of the standard allowed them to capture the Granny Smith market while the price is elevated.

Lessons Learned

This project demonstrated to be enormously useful as the CAC Board of Directors voted on the continued suspension/complete removal of the California Granny Smith Standard. Before the grant was concluded, there were various members of the Board of Directors that felt the GS Standard should be reinstated. Based on the information obtained by Dan Block & Associates, all CAC Board members realized that the potential for growth in sales with the Granny Smith variety was being hampered by the enforcement of the Standard. The data concluded, unequivocally, that on average the California industry was losing roughly $1.01 per box per year. With almost 1 million boxes of Granny Smiths being produced annually, the industry was giving away a lot of money. The drastic cumulative effect that the GS Standard had on industry revenues came as a complete shock. Most of the industry expected a variance, but no one anticipated the radical fluctuation of more than $1 per box. After speaking with California handlers and growers, it was apparent that they did not want to reinstate the Standard as the 2013/2014 Granny Smith season was better than the past. The research, including the Dan Block & Associates report, was distributed to the industry.

Additional Information

Attachment: Economic Impact of Removing the Maturity Standard for California Granny Smith Apples

USDA Project No.: 18	Project Title: Sauvignon Blanc Advocacy Group - Summertime in a Glass (SIAG)	
Grant Recipient: Summertime in a Glass (SIAG)	**Grant Agreement No.:** SCB12018	**Date Submitted:** December 2015
Recipient Contact: Bryan Dias	**Telephone:** 510-396-7276	**Email:** bryan@summertimeinaglass.org

Project Summary

This project was created to promote California Sauvignon Blanc. When the idea was originally hatched in 2010, the varietal was not performing well in the market, both for winegrapes as well as finished wine. This was due to several factors. One of the most important was its perception in the marketplace. It was often treated as a "commodity" grape (used in low-priced, high-volume wines of lesser quality). This mentality was perpetuated, in part, by lower price-per-ton prices being paid. Similarly, for consumers, Sauvignon Blanc, which had firmly been the "number 2 white wine varietal" (always a distant second to Chardonnay, but slipping due to competition from other white varietals, was losing popularity. It was also perceived as "a summer only wine" and suffered sales and marketing issues other times of year. This project sought to promote California Sauvignon Blanc and the region as producing a world class wine at a competitive price. Additionally, the concept was to promote the grape as a year-round, food-friendly wine.

With the above factors in play and with the economy recovering, it seemed the right time to develop this marketing concept and "Summertime in a Glass" (SIAG) was created. Other factors seemed to lend credence to the idea, with the recession declining, wine sales were ratcheting upwards. Within this trend, many wine buyers (such as millennials) were seeking "new things." Additionally, in the world of food and pairing, ideas were broadening widely to incorporate non-traditional cuisine (i.e. Asian, Creole, Mexican, etc.) with wine. Much of the mission of SIAG was to develop content and messaging to promote and educate on these trends. Additionally, SIAG developed (and continues to do so) original concepts that helped push the varietal forward. Educating growers, wineries, and the wine media/education segments of the wine industry was the focus of the project providing a resource for ideas, knowledge, and messaging. The growth of social media and online presence of wine and wine-related topics and sources (e.g. "wine bloggers") was a cornerstone of the project, seeking to reach these individuals and utilize these channels to "amplify" the California Sauvignon Blanc message.

Project Approach

This grant supported a marketing campaign and connected activities and programs to support and promote California Sauvignon Blanc. The "Summertime in a Glass" brand was developed with an appealing graphic look and concept designed to promote the varietal in California. A highly interactive and informative website was developed that houses content for both the wine industry and wine enthusiasts. The type of content on the site includes news, Sauvignon Blanc pairings, industry concepts and ideas, member profiles, and more. The website is now averaging over 2,500 page views per month. An aggressive social media campaign, utilizing various platforms, was created. This was a lynchpin activity, as it served as a primary point of outreach, Public Relations (PR), and information sharing to SIAG's audience. There are well-over 2,000 followers on social media. The regularly published email newsletter has 1,221 subscribers. An interesting online video-cast called "SauvBlancTV" was developed http://www.sauvblanc.org/calendar/sauvblanctv/. Episodes are shot on location, as well as online chats, discussing various issues connected to Sauvignon Blanc in California including harvest, winemaking, and grower topics. Eleven installments were created and shared on SIAG's website and YouTube. Four regional campaigns that focused on particular California Sauvignon Blanc producing regions were developed and carried out. The California regions were Arroyo Seco, Livermore Valley, Napa Valley, and Mendocino. The campaigns featured considerable content and outputs including a nationally distributed press release for each (making hundreds of thousands of impressions and boasting over 900 media pick-ups in total); a regional Sauvignon Blanc profile that discussed growing climate ("terroir"), flavor profiles, and more; and vigorous social media and website outreach and content. These were highly successful PR efforts that reached audiences throughout the United States and beyond exposing them to California Sauvignon Blanc. Additional press releases on harvest outlooks or retrospectives and other topics were also generated and found their way into popular media as well as wine industry outlets. SIAG, as of 2014, became one of three co-sponsors of "International #SauvBlanc Day," an immensely, popular global event that is largely social media driven. SIAG served as the voice of California Sauvignon Blanc reaching thousands of people. As a result of this, SIAG is seen as one of the "owners" of the hashtag "#SauvBlanc" on social media. This is very valuable and influential.

Other activities included three successful consumer wine tastings taking place in 2013 and 2014. The first was done in conjunction with WineLuv in November 2014 in San Francisco and attracted over 50 wine enthusiast attendees. The event was solely dedicated to showcasing California Sauvignon Blanc and exclusively featured several SIAG Member wineries showing their wines. The second was done in conjunction with the Lodi Winegrape Commission at their largest annual event, "ZinFest." The event featured a wine education demo hosted by SIAG Resident Chef, and Resident Master Sommelier. SIAG's Executive Director also presented to the crowd, numbering over 150 people, regarding SIAG and California Sauvignon Blanc. The third, was a tasting held at a local wine shop in New Orleans (a key target market for California Sauvignon Blanc) in January 2015 that had over 40 guests. All of the consumer events proved popular.

It was determined that a singular, "unified" industry workshop, as opposed to splitting into winemaker and grower audiences, was much more cost-effective and also, more importantly, more valuable by virtue of bringing these groups together. The event, "The California Sauvignon Blanc Symposium," took place in the centrally located and historic home of the grape in the US – the Livermore Valley. This was a highly successful event that brought together not only winemakers and growers, but also wine media, sales/marketing, sommeliers and wine educators. There were 43 attendees from around California and 100% positive feedback was received at the May 19, 2015 event. Two interactive panels were held that featured 1) three noted winemakers from California and 2) three acclaimed sommeliers. Viniculture, viticulture, and sales and marketing discussions took place. This was very valuable. Additionally, a technical tasting took place that encouraged excellent input and interaction. The key output of the event was a list of "talking points" for California Sauvignon Blanc that suggested strategies, practices, and approaches for promoting the varietal in California. This was published in a press release and shared with members, partners, and others in the industry. This output, critically, is being used to guide much of the future of SIAG moving forward. Another event took place after this event in Sonoma, California, and was billed as a "California Sauvignon Blanc Meet and Greet." Some 29 individuals representing growers, winemakers, media, and others attended this event at Kick Ranch Vineyard on May 22, 2015. Casual presentations, including sharing the symposium's outcomes, were made. Excellent discussions on key topics took place and these were used to further refine the talking points (before their publication) and other strategies. Also, for industry events during this period, SIAG partnered with Discover Sonoma County Wines (that also promotes and educates on other California regions) to put on a California Sauvignon Blanc seminar, primarily, for sommeliers and buyers. Some 22 attendees were present at the June 21, 2015 event. It featured the SIAG Resident Chef, providing education on pairing, and noted winemaker and charter member, co-hosting the event with SIAG partner and noted sommelier. Feedback was 100% positive for this event. A web-based story (with social media promotion) covered the event. These three events were treated as an industry "series" that kicked-off with promotion and discussion on 2015's International #SauvBlanc Day on April 24th. This allowed for a weeks-long "conversation" (largely online but also in press releases) regarding California Sauvignon Blanc coming into the summer months. As part of 2015's #SauvBlanc Day, member wineries and others in California were encouraged to host their events that day in their tasting room. A good examples is that 5 wineries in Monterey's Carmel Valley came together to host a group event in their tasting rooms. Also, as part of International #SauvBlanc Day in May 2014, SIAG partnered with New Zealand Wine to show Sauvignon Blanc at a tasting for industry in San Francisco, California, that hosted 30 wine buyers and media and an additional 20 winery representatives. SIAG represented California Sauvignon Blanc by showing several Napa members' wines.

Other notable activities included the hiring of two interns. The interns performed tasks including research, outreach, and assisting with social media. Three key "residents" were brought on-board assisting with content development, event presentations, education, and outreach and included a Resident Chef who generated tremendous wine paring education and content for California Sauvignon Blanc and regional campaigns. The Resident Chef regularly visited wineries to develop articles and recipes, which featured local, seasonal specialty crops. A Resident Master Sommelier provided wine reviews and critical educational content as well as vital outreach and partnership building. Lastly, a Resident Viticulturist worked with SIAG to discuss best-practices in growing California Sauvignon Blanc with a particular emphasis on sustainability (a critical theme to SIAG that has been promoted in various ways). Content on this subject matter was published on SIAG's website and also disseminated by the California Sustainable Winegrowing Alliance. A membership program, boasting 41 members (all but three are located in California) was created to enhance the Sauvignon Blanc community building, the sharing of ideas, a source of stories and PR, etc. was created. The membership program has brought together wineries, growers, support services (consultants, labs, etc.), and others from California's Sauvignon Blanc industry and, in many ways, forms critical relationships for the organization.

Many project partners were integral with this project. SIAG worked with several regional winery and grower associations to promote California Sauvignon Blanc, reach new constituents (mainly wineries and growers), assist with events, support outreach, and more. Primary partners in this regard were the Arroyo Seco Winegrowers, Mendocino Wine Inc., Lodi Winegrape Commission, Discover Sonoma County Wines, Wine Luv, and the Livermore Valley Winegrowers Association (LVWA). The LVWA was integral in supporting the May 2015 workshop – "California Sauvignon Blanc Symposium" that was highly successful. Also, of note, an Advisory Board was formed at the beginning of the project and continued to evolve and improve over time. The board boasts noted winemakers, growers, an attorney, a master sommelier, a chef, a viticulturist, a regional association director, and a marketing professional. Their contributions, support, and guidance were instrumental in the project. The credibility lent by these professionals to the project cannot also be overstated.

Additionally, numerous other partners, many of which are winery, grower, and other wine industry members of the organization, provided support, assisted with events, supplied content used in regional campaigns and PR efforts, social media content, writing/research, and much more. Essentially, the members and partners were the primary group used to "tell the story" of California Sauvignon Blanc. Similarly, these relationships were harnessed to build a community of Sauvignon Blanc producers in California. This was very evident at the industry events and general communication that took place throughout the project and continues today. Of course, a very positive outcome of this concept was an exchange of ideas, best practices, and networking that, undoubtedly, benefitted (and continues to do so) this community and the varietal in California.

Goals and Outcomes Achieved

The project proved very successful with nearly every goal being exceeded and, in several cases, greatly exceeded. Here are key outcomes:

Website page views – original goal: 1,000 month. The period of April to June 2015 saw 2,863 average views per month. May and June 2015 (an intense period of activities such #SauvBlanc Day and industry events that were well-publicized) saw an average of 3,053 per month. Interestingly, some 92.1% were new users during this period.

Media Mentions – original goal was six "significant" media mentions. Over all of the press releases, this number exceeded 1,500 media pick-ups. Press release impressions were in the hundreds of thousands. Additionally, three radio appearances in the key market of New Orleans were made promoting California Sauvignon Blanc. A wine media list has been created and is constantly updated for press release dissemination. PR Web, a very effective press release service, has been used for all of SIAG's national press releases and was, by-in-large, responsible for the dramatic results above. Additionally, SIAG has been mentioned or covered in a few wine trade publications as well as in numerous social media channels by others in the industry. The four regional campaigns were very successful and collectively enjoyed 922 media pickups. One of the most recent press releases highlighting California's participation in International #SauvBlanc Day garnered 245 media pickups.

Social Media Followers – original goal was 500. Currently, there are 2,077. Facebook (959) and Twitter (862), two primary platforms, have individually exceeded the goal. Over 3,200 tweets have been generated during the course of the project as well as hundreds of Facebook posts, for example. A LinkedIn group was created for industry to interact and share related topics. These, along with other platforms, have given a strong, consistent, and regular presence for California Sauvignon Blanc on social media. An additional positive of this is that many of SIAG's social media followers are in the wine industry – writers, bloggers, producers/vintners, retailers, sales reps, media, etc. – and they help "amplify" the message by sharing posts and content consistently.

eNewsletter – original goal was 1,000 subscribers (please note that separate industry and consumer eNewsletters were quickly scrapped as it was clearly more effective to have one newsletter.) After a recent list "cleanse" the number is 1,221. A more "informal" email communication has been used since the beginning of the project that keeps members, partners, and occasionally others (such as media) informed.

Consumer Event Participation –The original concept was to host one consumer showcase in Lake County. The approach was changed to hold more than one singular event in order to increase reach and effect as the project's strategy changed. The final goal for event attendance, however, is 200. This goal was met by attendance of over 150 at Zinfest, the San Francisco event that hosted over 50 wine enthusiasts, and a California Sauvignon Blanc tasting held in the New Orleans market at a wine shop that showcased California's varietal with an estimated 40 attendees. Similarly, the wine tasting in New Orleans was casual, but clearly had 40+ attendees over the course of the evening). Total number of attendees is approximately 240. As part of #SauvBlanc Day efforts in 2015, eight different events took place at wineries around

California. Due to the casual nature of these events taking place in tasting rooms, it is not known how many consumers attended the events, but they certainly pushed the consumer numbers even higher for the project. Also, of importance, is that social media, media, and web content (such as wine pairings by the Resident Chef) have reached thousands of people in an ongoing, engaging fashion. When considering the "amplification" and sharing by others (including member wineries sharing content on their websites, social media, and eNewsletters), SIAG's connection with consumers was very successful.

Industry Event Participation – The original concept was to host two grower and one winemaker workshop. It was assumed that, over the two grower workshops, audiences would be much the same (meaning, many repeat attendees.) The original goal, in total, was 135 attendees across the three events, but, again, not necessarily "unique" attendees at each. The four industry events reached a total of 124. However, this represents 122 unique attendees. Two persons who attended California Sauvignon Blanc Symposium in Livermore, California, attended the later event in Sonoma, California, SIAG's industry networking and discussion event. Additionally, it was originally expected that, at most, four California regions would be represented (Lake County, Sonoma, Napa Valley, and Mendocino.) Those four regions were represented by attending at least one event. Four additional California regions were represented similarly: Livermore Valley, Arroyo Seco/Monterey, Sierra Foothills, and Lodi. This represents a considerable increase of reach beyond what was originally envisioned. The breakdown is as follows: California Sauvignon Blanc Symposium – 43, Industry Meet and Greet (networking event) – 29, Sommelier/Buyer Seminar – 22, and #SauvBlanc Day Tasting – 30. Please also note that the last listed event here, the tasting, excludes the 20 winery representatives present. If those are included, the total number would be 144. The original goal for workshop feedback was 75% positive. The primary industry event, the symposium, garnered 100% positive feedback. Attendees were asked to rate the event as being "informative and helpful" on a scale of "strongly agree, agree, indifferent, disagree, strongly disagree." All but three respondents indicated "strongly agree" with those three indicating "agree." Additionally, the other "formal" event, the buyer/sommelier tasting similarly had 100% positive feedback. The other two industry events (networking event and #SauvBlanc Day tasting) did not lend themselves, due to format, to a formal survey, but feedback was positive for both.

Membership –It was originally envisioned that Lake County growers and wineries, due to SIAG's specific focus there, would represent the vast majority of members and would also represent a significant majority of all the growers and wineries in that region with, perhaps, a few other members from the other North Coast regions (Mendocino, Napa Valley, Sonoma.) The original outlined goal was a total of 65 growers, 50 wineries, eight partnerships, and three sponsors. To date, SIAG has 41 total members with 38 based in California. This represents five independent growers, 25 wineries (24 in California – many of whom are also growers), three regional associations (effectively, "sponsors," as they assisted with outreach, events, and recruitment), and eight trade members (six in California.) There is a great deal of overlap in how "membership" is now defined and how both "sponsors" and "partnerships" were originally envisioned. SIAG has worked with numerous organizations and individuals not listed in the membership ranks. However, there are six additional, meaningful partnerships not covered in membership. Perhaps, more importantly, membership and other relationships have been formed in a larger number of regions than originally anticipated – Lake County, Sonoma, Mendocino, Napa Valley, Livermore Valley, Arroyo Seco/Monterey, Mariposa, and Paso Robles. Additionally, since much of the audience is representative of a broad swath of the wine industry – growers, wineries, sales/trade, media, and educators, a tremendous industry audience over the course of the project has been reached.

Print Distribution – original goal was 70 businesses receiving collateral. With this project, 84 known businesses received California Sauvignon Blanc recipe cards. Undoubtedly, more received the cards as they were distributed at the consumer tasting in San Francisco and at Lodi's ZinFest. Over two thousand were distributed. It was noteworthy, that SIAG emphasized non-print (such as social media and web-based content that could be shared by wineries to their customers, wine media, etc.) as the project evolved. This was more cost effective, allowed for a much broader reach, and significantly widened the breadth and focus of the content.

Long-term measures relate to sales numbers, primarily. With the original focus on Lake County, the idea was centered, largely, on promoting that region collectively. By shifting to other areas and a broader reach, this became less focused and, likely, more difficult. Similarly, measurements were more difficult (in fact, many regions are not completely clear on how many acres are planted, for example, for each varietal.) The original Lake County-oriented goal was a 5% increase in price per ton for "participating" growers and 10% in sales of the varietal for "participating" wineries. From the baseline of 2010 before the project started, the average price per ton of the varietal in California was $709.11. By 2014, the latest numbers available, that number had risen to $956.11. This represents a substantial increase of 34.88%. Also of note, the Sauvignon Musque clone (which is indeed a clone and not a separate varietal but is tracked separately by USDA in the California Crush Report) went from $1,481.24 per ton in 2010 to $1,655.17 per ton in 2014. This is an 11.74% increase. Between reporting members (many did not) and those at the symposium that did report (some did not), the known number of acres is 523.19 "affected." This represents, approximately, 3.4% of California Sauvignon Blanc vineyards. When considering those that did not report and how many operations were affected by SIAG in some fashion (i.e. articles on sustainability in the vineyard, news and information, sales concepts, messaging, etc.), this number is surely considerably greater.

Again, winery sales became difficult to track and the geographic spread "diluted" the single regional effect of winery participation (a percent of that single region). However, it is clear that California Sauvignon Blanc sales have increased, including the over $20/bottle price point. In 2014, US Sauvignon Blanc (of which the vast majority comes from California) maintained a robust 4% market share across all varietals (this was also true in 2013), according to Nielsen. This is considerable and it was identified by Nielsen in 2014 that the "hottest" off-premise varietals in the US were Sauvignon Blanc, Pinot Noir, and Cabernet Sauvignon. Anecdotal information widely seen in the industry is that US Sauvignon Blanc (and, obviously, that in California) is enjoying somewhat of a renaissance. More winemakers and chefs, for example, cite the grape as a favorite. It has become known for being a year-round food wine (a message this project pushed consistently). This project and SIAG has, undoubtedly, been integral in promoting these messages, ideas, and the overall exposure of California Sauvignon Blanc.

Beneficiaries

The primary beneficiaries are the 50 plus Sauvignon Blanc wine grape growers and the wine grape industry. It is clear that SIAG members (38 in California) benefitted through marketing, participating in the community that was built, and exchanging ideas/learning (i.e. from industry events.) Similarly, the approximately 74 businesses (wineries, growers, buyers/sommeliers, and other wine trade) that attended various events benefitted from the project. The well-over 2,000 social media followers and the thousands of website visitors, many of whom are in the wine business in some fashion, benefitted from this project. A good example is the audience SIAG developed with those who sell Sauvignon Blanc – sommeliers, wine buyers, restaurateurs, sales reps, etc. – SIAG's rich content, education, and messaging clearly has assisted these groups, though their actual numbers are difficult to quantify. Lastly, wine enthusiasts/consumers that attended the events or explored the content (for example the tens of thousands reached in press releases with content and messaging promoting California Sauvignon Blanc or received recipe cards) presumably benefitted in some fashion. The overall reach of the project to various groups was much greater than originally anticipated.

In addition to the above, the potential to impact either directly or indirectly the approximately 15,400 acres planted to the varietal in California exists. The 34.88% increase in average price per ton over the course of the project is a significant impact. Similarly, increasing sales and notoriety for both the varietal and California's role in producing it (many the talking points generated by the symposium illustrate this and will continue to be utilized to promote the grape, build partnerships, develop content, etc.). Certainly, this project alone is not solely responsible for these increases, but clearly it contributed significantly and directly.

Lessons Learned

As a marketing project, many things evolved over time. From the beginning, the significant change in strategy from a Lake County focus with a concentrated effort caused a great deal of change and adaptation. The idea was to focus there and, at the end of the project, "step-out" to immediately neighboring regions as a means to "set the stage" for the next round of the project. Reality was quite different. SIAG adapted quickly, however, to this dramatically changed landscape. Plans to expand to other regions immediately took place. This increased the reach of the project and, likely, also grew the overall audience and reach of messaging. Also, this significantly increased the number of partners with which the project worked and took it to "new places" both literally and figuratively. However, this took away the ability to focus on one region, methodically. Certainly, this affected membership growth (it was presumed that it would be easier to gain a larger level of participation within a specific region and then expand outwardly in a more step-by-step process). It also affected the ability to track direct results for sales and acres affected, to some degree, in a more focused fashion than a region-by-region approach. Additionally, it required that the project be extended on more than one occasion. This was positive in that it allowed both more time to exceed certain goals and to take advantage of new opportunities. However, a more succinct, geographically focused project was originally envisioned. That being said, the project reached many more people than originally intended and affected more of California Sauvignon Blanc than what had been envisioned.

Also, the shift to a wider reach connected with a more cost-effective approach. The project more fully embraced and leveraged electronic media (web, social media, and press release distribution) and continues to do so. This allowed the project to reach tens of thousands of individuals in some fashion as opposed to the few thousand thought possible originally. Also, the building of key partnerships and relationships (partners, members, etc.) allowed for an increase in the number of events supported. This broadened the reach and location of the project as well. It is clear that a marketing project requires adaptability and seizing the opportunities as they come. A good example is as the geographic focus increased to more areas of California, the creation of the regional campaign concept was very beneficial. Also, many new ideas for content (i.e. wine pairings for specific California Sauvignon Blancs and much more) were developed well beyond what was originally envisioned. This was highly effective.

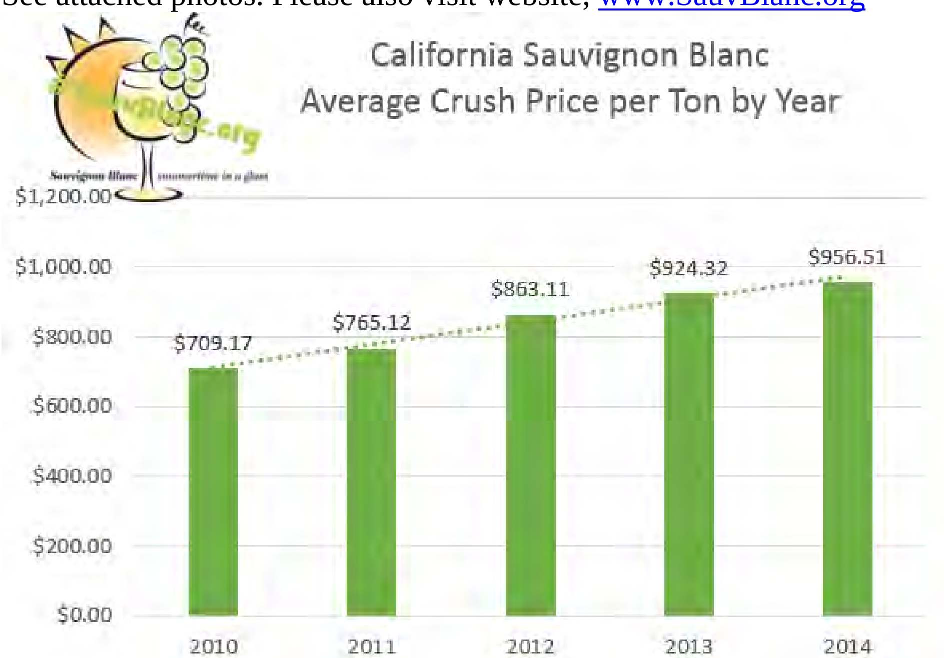
An unexpected outcome that was an effect of this project included the media impact that went from an original goal of six media mentions to well over 1,500. The growth of social media and the effect it had on the project's ability to reach a broader audience was a tremendous development. Also, the project's audience (especially on social media) demonstrated to be a much larger group of wine industry individuals, especially those in the media, bloggers, and sales reps. This was realized and the strategy adapted to message to those individuals who, in-turn, helped amplify the project's message in their work, writings, etc.

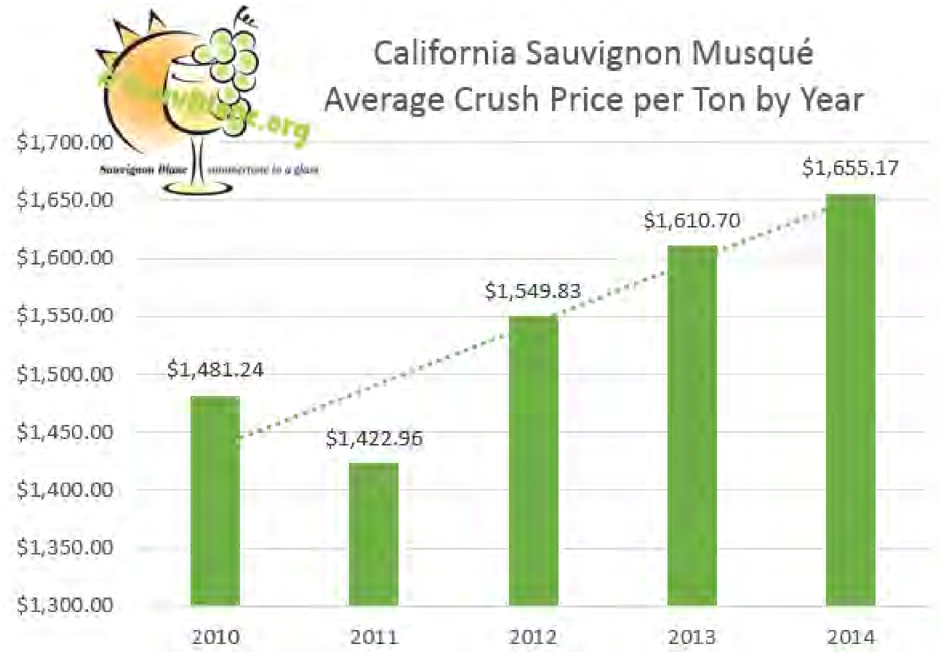
It became clear that grower involvement was predicated on winery involvement (meaning, someone to whom to sell their grapes). With the original concept, the idea was to raise the profile of Lake County Sauvignon Blanc, first and foremost. Bolstering that region's image and, ideally, sales and appeal would have made it more feasible to attract the grower audience and, additionally, a larger majority of that region's wineries. This also affected the ability to, in turn, affect the amount of acreage and increase in sales originally envisioned for the region. Essentially, the original targets in these regards were rendered somewhat irrelevant as the focus changed to reach more individuals and regions, perhaps, with less direct and targeted measurable impacts, but much broader in effective reach, messaging (i.e. more on "California" and less, specifically on "Lake County") and sheer numbers of people exposed to the project.

An adaptive strategy must be considered for marketing projects to take advantage of the emerging positives and opportunities and mitigate the negative dynamics and realities.

Additional Information

See attached photos. Please also visit website, www.SauvBlanc.org





Links to social media channels: http://www.sauvblanc.org/about-us/connect-with-siag/

More info and examples of recent activities:
http://www.sauvblanc.org/siag-co-sponsors-california-sauvignon-blanc-single-varietal-tasting-with-discover-sonoma-county-wine/ (included pictures of the sommelier/buyer seminar)
http://www.sauvblanc.org/summertime-in-a-glass-brings-california-sauvignon-blanc-industry-together/ (info and pictures from the symposium and the networking event including the key output of talking points and strategies for California Sauvignon Blanc)
http://www.sauvblanc.org/excellent-2014-harvest-bring-top-quality-california-sauvignon-blanc-2015/ (press release on the 2014 California Sauvignon Blanc harvest and the outlook for what to expect in the marketplace in 2015)
https://www.wineinstitute.org/resources/pressroom/05192015

Regional campaigns (much of the content can be seen or is linked to here):
http://www.sauvblanc.org/discover-arroyo-seco-sauvignon-blanc/
http://www.sauvblanc.org/discover-livermore-valley-sauvignon-blanc/
http://www.sauvblanc.org/discover-napa-valley-sauvignon-blanc-siag-regional-profile/
http://www.sauvblanc.org/siag-spotlight-mendocino-county-sauvignon-blanc/

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 19	**Project Title:** El Dorado Winery Association Education and Public Relations Campaign	
Grant Recipient: El Dorado Winery Association	**Grant Agreement No.:** SCB12019	**Date Submitted:** December 2015
Recipient Contact: Terrie Y. Prod'hon	**Telephone:** (530) 622-1731	**Email:** terrie@mountaukum.com

Project Summary

The El Dorado Winery Association (EDWA), with members located in two unique high elevation sub-appellations of 90 wineries and 100 grape growers with 2,250 vineyards acres amid rolling foothills of the Sierra Nevada Mountains, has doubled in the last 10 years. Growth has provided the critical mass now needed to expand media, trade and consumer awareness in and beyond nearby Sacramento and Reno markets. Additional key affluent wine markets of San Jose and Greater San Francisco Bay Area, plus Lake Tahoe, have not been explored or courted to grow sales of EDWA wine. Marketing has not kept pace with growth. Research exploring consumer awareness of El Dorado County (destination, brands, varietals, vacation stays) undertaken at the beginning and end of the campaign will create the foundation for enhanced website and educational tools facilitating key audience access and understanding of the region's high-elevation terroir. A multi-faceted public relations program, buttressed with social media and brand-building marketing events in key markets for trade and media, will grow EDWA awareness and wine sales. Geo-tourism and business partnership that celebrate the character, environment, culture and history of the region should be pursued. In addition to its current focus of white water river rafting, hiking, skiing, Gold Country, and fruit orchard, El Dorado County must be positioned as a destination for premium wine products and a unique & different high-elevation wine tasting experience, in addition to its current focus of white water river rafting, hiking, skiing, Gold Country, and fruit orchards. As sub-appellations of the greater Sierra Foothills American Viticulture Area (AVA), EDWA's quality wines produced by mostly family-owned boutique wineries should be elevated and moved out from the shadow of those of neighboring Amador County. "Bring Out the Barrel" weekend in January, "Passport Weekends" in Spring, "Fair Play Wine Festival" in June, "Placerville Art & Wine Festival" in October need to be positioned as important wine events on state and regional wine consumer calendars.

With the increase in the number of vineyards and wineries, the downturn of the economy, and increase in the cost of gas this project could be perfect in its timing. More vineyards have been planted and they are continuing to be planted. This leads to more need for wineries to buy and produce wine. EDWA has learned through this project that El Dorado's high quality grapes are extremely desirable by other regions and they are in demand. New local wineries are required to produce wines using at least 50% El Dorado grapes. Most of the wineries in EDWA use much higher than the 50% required. To be able to produce more wines a winery must have more sales. With most of EDWA wineries being small, boutique, and family owned it leads to the need for more people coming to explore the wineries. The cost of gas became an important factor for the need to publicize the qualities of the El Dorado Region so that gas prices would not become a barrier to consumers to come to the region. This project has allowed EDWA to develop and execute a targeted marketing strategy to begin to assist the wine writer world to not only finding, but paying attention to, this growing wine region. EDWA plans to not only continue this program, but increase the efforts to continue the promotion momentum and keep the region in front of the writers, trade, media, and more importantly the consumers. If attention to and advertising of El Dorado wines fades so too will it in the minds of these targeted audiences.

Project Approach

1: Benchmark Market Research – Stonebridge Research performed the first survey. The key take away of the research indicated an overall lack of awareness for El Dorado wines among key audiences: consumers in California and Nevada. The original plan was reviewed with research results in mind. Areas of the program were tweaked, but the key focus on building awareness among the media and trade stayed intact with the benchmark data now complete. An unusual development that EDWA learned was that the Amador County region, which EDWA thought had higher visibility, actually did not. That region was as equally unknown as El Dorado, as well as the entire Sierra Foothills region lacked consumer awareness.

Full Glass Research performed the second survey. The consumer sample for 2015 was recruited from the same key audiences as the 2013, with the same criteria. The demographic and wine drinking characteristics of the 2015 study respondents closely paralleled the available data from 2013, with two exceptions: the ratio of California to Nevada residents, and education, where the 2015 respondents showed a significantly higher proportion with a graduate degree. The ratio of California to Nevada residents was deliberately changed to better match the actual market for El Dorado wineries. Interesting things learned:
A. Quality and value ratings for El Dorado wines were significantly higher among those who had attended El Dorado events or read/viewed media on El Dorado wines.
B. There is a genuine correlation between the exposure and the quality/value ratings for the Sierra Foothill regions.
C. Those exposed to El Dorado through various media were also somewhat more interested in attending wine-related festivals or events.
D. El Dorado's relationship with the other foothills regions: there were dramatic differences between event attendees or those exposed to El Dorado through the media and other El Dorado visitors. These two groups were more opinionated on the subject and far less likely to be neutral.
E. Those who attended El Dorado events and were exposed to El Dorado through the media are more engaged wine consumers in general, and have formed a clearer picture or have greater involvement with the Sierra Foothills as a wine region. This aligns with the respondent's higher likelihood of residing in the region or nearby.

Differences noted between 2013 and 2015 results:
A. Association of El Dorado as an "up-and-coming" wine region decreased from 23% to 14%; association of El Dorado with "friendly, family-run wineries" increased from 20% to 37%.
B. Perception that Sonoma wines were widely distributed increases from 54% to 79%.
C. Association of Amador with a "great variety of wines" increased from 21% to 23%, while association of Amador with white wines declined 33% to 12%.
D. Characterization of Lodi as an "up-and-coming" wine region declined 28% to 17%.
E. Although the measures were not directly comparable, it is clear that the number of respondents who visit wine regions and the respondent's frequency of visitation increased moderately.
F. The proportion of those who characterized the El Dorado wine region as "hard to get around, out of the way" declined from 22% to 15%.
G. The proportion of respondents who associated El Dorado with good food, shopping, and luxury hotels increased moderately from low levels (7% to 10%, 4% to 8%, 2% to 6% respectively).

EDWA will continue the promotion and marketing started with this project. The recently formed infrastructure committee has their work cut out for them, but from what was learned since its formation was deemed necessary after the 2013 survey, it is something that has made progress in the correct direction. EDWA is moving forward with getting working relationships with other Sierra Foothill winery associations, tourism councils, and marketing organizations. Working together will pool resources, funds, and getting strength in numbers will help get the Sierra Foothill region the attention it deserves.

2: Educational Website and Marketing Tools – Mobile website: www.eldoradowines.org was launched May 19, 2013. Since then there have been 87,566 visits to the website, broken down mobile 21,691, desktop 54,143, tablet 11,732. Elevation map was completed which shows in detail the elevations of El Dorado Wine Country vineyards and wineries, and reinforces the motto "Taste at Higher Level," and four tasting and touring maps which allow a self-guided tour of El Dorado Wine Country were created. Tours can be downloaded from the website. Video vignettes were added April 27 to June 16, 2015. Currently there are 3 loaded, with 463 views. AVA map and tasting map templates were done for the June 3, 2014 trade market visit, and website enhancements and upgrades were completed throughout the project.

3: News Bureau and Public Relations Campaign– Five Familiarization Tours were held, November 5-7 2013, March 4-6 2014, November 4-6 2014, March 1-3 2015, and May 5-7 2015. There were a total of 27 journalists that were brought to the El Dorado region, additionally four one-off writers came as well.

Themes for media shipments were decided, wine writers were carefully selected for specific themes, and twenty-five wineries submitted their wines to be sent out to writers in April of 2013 through June 2015. Over 338 bottles of wine were sent out to 91 writers and bloggers.

Twenty four newsletters and 12 press releases were produced.

For these efforts there were many articles written. Total Media Circulation 401,748,046, Media Impressions 1,004,370,115, and Equivalent Ad Value $1,163,144.44.

4: Social Media – As part of EDWA's match it was decided to start the social media campaign in year one. Facebook postings are done 5 days a week. Twitter was integrated into the daily social media conversation and wineries were encouraged to and did join in the dialogue. Instagram was introduced in the second quarter of 2014. An annual campaign was developed for 2014 which introduced a theme for each quarter. Quarter one was Wine Quotes, quarter two was Winery Pets and their clever observations of life at an El Dorado Wine Country vineyard and winery. Quarter three presented a theme of wine crafts, beautiful and functional items that can be fashioned and repurposed from discarded wine bottles, corks, labels or any other wine related product. The theme for fourth quarter was Wine Country Views, which showcased the natural beauty of the El Dorado region, and the wonderful seasons that include the annual crush and holidays through Wine and Food pairings. First and second quarter for 2015 was Wine Grams. Started a Blog on May 1, 2015 using writers from three different generations to engage and effectively communicate with all generations interested in wine.

5: Market Visits - There were two major production market visits held. One was June 3, 2014 at Mulvaney's in Sacramento, California. There were 38 attendees from restaurants, press, magazines, and hotels. The opening panel consisted of 6 local writers and a notable winemaker from another region that uses grapes from the El Dorado region. There was a keen interest in the diverse soils and elevations that El Dorado's grapes are grown in. June 3, 2015 the second one was held in Oakland, California at Marc 49. There were 75 plus trade and media attendees. It began with a trade walk around tasting with 16 wineries participating, and wine bar tastings held at three venues with 9 wineries participating and 75 plus consumers attending. The diverse opportunities to present the wines of El Dorado addressed participant's desires to have access to consumers, trade buyers, and writers. In addition, due to partnering with Touring and Tasting Magazine and Zinfandel Advocates and Producers, EDWA also participated in California Wine Festival and Winter Wine Classic in Santa Barbara, California and Zinfandel Advocates and Produces January event for two years.

During this project EDWA was able to get Touring and Tasting Magazine to understand the quality of the wines of El Dorado. They sponsored EDWA at two important events, California Wine Festival and Winter Wine Classic in Santa Barbara, California, to show the wines to consumers that normally would not have been exposed to them. Zinfandel Advocates and Produces (ZAP) have annual events in San Francisco, California, and they wanted El Dorado's region to be present to showcase EDWA's wines. The ZAP members that were also EDWA members contributed to reduced cost and EDWA was able to be there two years in a row.

Goals and Outcomes Achieved

Benchmark Market Research – EDWA's first survey gave the Public Relations (PR) Committee information that lead to enhancing the topics of future Familiarization (FAM) tours. The Market visits locations were also driven by the results of the first survey. When EDWA did the second survey the data was gathered to compare with the first one, but also gathered data in order for the PR Committee to design the future promotion's campaigns.

Educational Website and Marketing Tools – EDWA's website continued to be improved after the work that was done with grant funding in years 1 and 2. EDWA, funded out of matching funds, continued improvements for year three. Many times the first impression of what the Region is about is found by visiting the website. EDWA learned that that first face needs to be crisp, clean and easy to navigate to get the information the consumer needs to decide to come visit El Dorado. Adding self-guided tours and Video Vignettes are great tools that were added along with changing the overall layout and attractiveness of the site. This will be an ongoing, continuing project. Creating American Viticultural Area (AVA) maps and tasting templates were also important to let writers and consumers not only know the location, but what EDWA is about. Additional pieces produced let all know that EDWA has over 50 varietals of grapes, diverse soils, elevations ranging from 1200 to nearly 4000 feet, and diverse micro-climates. Those characteristics were deemed to be important as EDWA put together its story to promote the region.

News Bureau & Public Relations Campaign – Developing the press kit was the first step for the PR Campaign. This was done in conjunction with the Board of Directors, Public Relations Committee, and both consultants we hired. The initial press list was developed by Solterra and added to by Infuze and the PR Committee. An interesting development was that over the course of the project writers and bloggers reached out to be added to the list. Initially EDWA planned for two FAM tours. After the first one took place EDWA learned that getting more writers here would be a key to getting more publicity, thus EDWA ended up doing 5 tours. A year round campaign was developed and newsletters and press releases were written and distributed to initially expose the Region to writers, bloggers, and consumers, and to keep the Region in front of them and constantly reminding them about its wonderful, unique, and exciting qualities.

Social Media – EDWA's PR Committee presented to EDWA's Board the need to fund and start this part of the campaign in year one rather than waiting until it was funded in years two and three. The Board approved the early launch of the Social Media program. EDWA had Facebook and Twitter accounts and during the three years added Instagram, Pinterest, Steller platforms, and finally added a blog. People come and go from viewing sites. Content must be ever changing and interesting to keep them engaged and the numbers growing that are interested in staying in touch with what's going on in El Dorado.

Market Visits – It was interesting to learn, as EDWA planned these two Trade Market Visits that first the project team needed to reach out to the Sacramento area because, in general, most here did not know about the El Dorado wine region. This was learned from the first survey conducted and the initial contacting of press in the area. EDWA's first focus was on trade as well as some local press. When the planning began for the second Visit the members let the PR Committee know that not all wineries were interested in securing the members wines in restaurants and stores and that the consumer element was where they wanted to see more effort. With the partnering that was done with Touring and Tasting and ZAP EDWA was able to expand the consumer presentation of El Dorado Wines.

Long term and continuing PR will be needed in order to keep El Dorado in the forefront of consumer's minds as the place to go to get quality wines and wine tasting experience. Growing website visits and social media engagement will be key tools to use, as well as continuing newsletters, press releases, FAM tours, and Market visits. EDWA's Board is planning on funding these continuing efforts. Part of the this targeted strategic planning is to continue to develop relationships with other AVAs in the Sierra Foothill region and Visitor/Chambers Bureaus to promote El Dorado and the Sierra Foothills as a wine destination. Working together and with local governments EDWA plans to facilitate getting infrastructure (lodging, restaurants, and shopping) needed to support an influx of visitors and make it more attractive for them to visit. EDWA's infrastructure committee, which was formed as a result of information learned from this grant, and newly forming government relations committee will spearhead this effort.

The primary goal of the El Dorado education and public relation campaign was to grow awareness among media, wine trade and consumers. The work plan allowed maximum results to be achieved through a variety of tactics including:

Benchmark market research – Completed the benchmark and final surveys. The intent of the benchmark studies before and after the campaign was to help El Dorado position itself by understanding the perception and key barriers among consumers. Both studies targeted 1000 consumers in California and Nevada. The data concluded that marketing and tourism infrastructure continue to be the core challenges of the region. El Dorado has established an infrastructure committee and has begun creating strategic partnerships with regional wine and tourism groups to help broaden awareness of the greater regional area with the intent to increase consumer awareness of El Dorado wines.

Educational Website and Marketing Tools – Continued enhancements to website and added Video Vignettes. The goal was to create new educational and marketing tools to help expand awareness of El Dorado wines. Site traffic to the website through mobile and tablet devices now accounts for 38% of the overall views.

Adding a new AVA map, 3 new videos and more key facts keeps interested consumers coming back to the site which increases its usefulness as a core marketing tool.

News Bureau & Public Relations Campaign – Held the fifth FAM tour. Announced "Endulge El Dorado Blog". The goal was to establish a year-around communication program targeting the media with relevant information. Thirty-one journalists were hosted as part of the familiarization tour program, 11 more than originally planned due to the interest of the region. Ninety-one journalists received wine samples to educate and garner interest in the region. Twelve press releases and 24 newsletters communicated relevant content to the media and kept El Dorado wines top of mind. Media impressions were quantified at 1.0 billion impressions outpacing the intent of up to 3.0 million impressions. The new blog, Endulge El Dorado was created in 2015 to support ongoing efforts of providing content about El Dorado wines to keep media, wine trade and consumers engaged.

Social Media – Started a Blog and continued postings on Facebook, Twitter, Pinterest, Instagram, and Stellar. The goal was to enhance activity on social media channels. Developing social media channels with content about El Dorado wines supports the year-around education and communications campaign. Establishing these networks resulted in more audience engagement through Facebook: 3,220 followers; Twitter: 558 followers; Instagram: 880 followers; Established Pinterest boards and a Stellar account. The blog: http://www.endulgeeldorado.com provides regular content to engaged followers.

5. Market Visits – The goal was to create brand-building seminars in key markets. Two educational seminars and walk around tastings for trade and media were held during the grant period. One in Sacramento and one in Oakland, both key markets for El Dorado wines for wine sales and wine tourists. One-hundred ninety-four buyers, media and consumers attended the two market visits. The outcomes were feedback from key sales persons about impressions of the wines. The Oakland market specifically embraced the El Dorado region with connections made for relationships that will garner future results.

EDWA's potential impact was to significantly benefit more than 4,500 local business that are primarily family owned and operated. The number of wineries and grape growers has increased. All project deliverables have been complete and the anticipated outcomes in each area were met. However, as the industry grows and the next generation begins to take over the day-to-day management ongoing education and awareness is vital to the success of selling El Dorado wines. The project allowed El Dorado to create a foundation for building awareness and education, but as more wineries are looking to sell directly to the consumer it's critical for the area to establish strategic partners within other Sierra Foothills wine groups, regional tourism groups and other agricultural groups to promote the region and continue educating media, wine trade and consumers about the quality wines and unique experience the region offers.

The major successful outcomes of the project are as follows:
Two Benchmark Market Research Studies were completed. First one helped PR Marketing committee, Board, and Consultants refine the PR campaign and the second one showed the successes and will guide the EDWA Board to drafting campaigns in the future.

Website visits since October 1, 2012 were 87,566.

FAM tours brought 27 writers to the Region, as well as four one-off writers. Sent out 12 press releases. Produced and distributed 24 newsletters. Media Impressions totaled 1,004,370,115, Media Circulation 401,748,046, and Equivalent Ad Value of $1,163,144.44.

Social Media followers have grown from 3,209 to 4,581. EDWA's blog was launched May 1, 2015 and by the end of June 2015 there were 427 views.

Held two trade market visits, one in Sacramento, California with over 38 trade in attendance and the other in Oakland, California with over 75 in attendance. Going to Santa Barbara and San Francisco, California two times each put the Region's wines in front of over 5,000 people that would have most likely not experienced tasting them if EDWA had not done the events. Doubling the participation each area also allowed EDWA to see the growth in the number of people who had experienced the wines at these two pouring's and learned firsthand, though interaction with participants, that some were motivated to actually purchase El Dorado wines either from websites or from visiting the area after the first pouring.

Beneficiaries

Quality wines start with outstanding grapes. Over one-hundred grape growers, representing 2,250 vineyard acres were highlighted due to their grapes being showcased in El Dorado's wines. Many also were interviewed by writers that came or inquired about the region. It was noted in many stories that the demand for El Dorado grape grower's high quality fruit was turning into sales for many winemakers outside of El Dorado.

El Dorado County wineries received lots of positive press due to this project. With more people coming here and/or learning about El Dorado County's wines business has increased for local lodging, restaurants, and business. More people equates to more business. Learning that people need a wide range of options for things to do when they come to a region has led EDWA to publicize the attractions that can accomplish this. An example of this is El Dorado's Gold Country history that led to migration west and ultimately to grapes being planted and wineries being established. Also, during this time the project has also helped to attract additional winery memberships and associate memberships by adding value and benefit the existing membership. Winery memberships grew 17% and associate memberships grew 50%.

Over 4,500 businesses in El Dorado County had the opportunity to expose themselves to the writers, bloggers, and people the campaign brought here.

EDWA's 41 wineries had many opportunities to showcase their wines by inclusion in wine packs, mentioned in stories, and participating in FAM tours, and/or Market Visits.

Lessons Learned

Educational Website and Marketing Tools – After the initial improvements, EDWA saw great improvement in the numbers of people who visited the website and has continued to see increased usage as more content is added and refined. Having the educational tools to describe the region has been a great addition. It also has given the wineries the tools to demonstrate to visitors the unique characteristics that make up El Dorado: over 50 varietals grown, diverse climates, elevations from 1200 to nearly 4000 feet, and soil types.

News Bureau & Public Relations Campaign – When the program was initially put together the plan was to have 10 to 12 writers for each of two FAM tours. It was discovered after the first tour, when EDWA needed to keep the number of writers between 4 and 6, that if more tours were added, it would improve both the FAM tour infrastructure and the attention needed to be given to the writers. Having time for one-on-one discussions attracted additional stories because requests could be met that would not have been able to be done if a bigger group were assembled.

Social Media –This element was an extremely important part of the advertising campaign, especially to start dialogue with the future wine consumer. Having the educational elements and fun themes helped engage the people who use this method to gain information and communicate. Education has and will continue to be important. EDWA has now started having wineries submit a picture of what is happening at each winery to be used for this portion of the postings.

Market Visits - The initial response to invitations indicated that there would have been nearly double the 38 that attended. Having the panel discussion to open the visit was a wonderful idea and had excellent interesting content, but for trade people it was not what they were looking for. At the walk around tasting EDWA had a lot of wines from many wineries to try, but not having individual wineries there to represent their wines made the results from that effort not what was hoped for. With the second visit EDWA took the lessons learned and the suggestions from members and changed up the format and content. Having the winery owners or their representative's pour for the walk around tasting nearly double crowd from the first market visit was truly more successful. Finally adding the consumer element really pleased the members and El Dorado wines were presented to 70 additional potential customers.

Unexpected outcomes that were an effect of implementing this project are as follows:
Benchmark Market Research – Learned from the first survey that the Sierra Foothill Region as a whole was not known. Most wineries in El Dorado believed before the survey that Amador had huge recognition, but learned that it was as unknown as El Dorado. Have started reaching out to other AVAs in the Sierra Foothills to start joining forces to work together to get the word out that there is an abundance of high quality wineries and wines on the eastern side of California.

Education Website and Marketing Tools – It was extremely difficult and way more costly than originally thought to get a topography map of the El Dorado Region.
News Bureau & Public Relations Campaign – Meeting with small groups of writers is much more productive than large ones. Putting together the elements for stories that describe the varied and unusual aspects of the region allows the Consultants and the PR Committee to give ideas and direct writers for interesting results. More training is needed for the wineries that participate. EDWA needs to make sure that everyone participating FAM tours understand the message and talking points so that they convey the message of the Region.

Market Visits – Cost to put one on is a lot higher than originally thought. Getting the vendor participation was difficult and EDWA learned that you need to ask and get confirmation from nearly double the people that you want to attend.

Initially it was thought that promoting events would help bring more people here. It's interesting to note that two of the four events mentioned, Bring out the Barrel and the Fair Play Wine Festival, are no longer taking place. EDWA's Board in conjunction with Event and PR Committees are looking into things that can accomplish the goal of promoting the Region.

EDWA's goals were all met. All of those participating need to evaluate each element on a regular basis, listen to what the results are telling, and then be flexible to make the changes that are indicated. Marketing isn't something that can be done one time well and then continued in the same manner with less cost. It needs to be updated and refreshed to keep people engaged and wanting to continue to visit the region and buy wines.

Additional Information

See Attachments 1-2

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.:	Project Title:	
20	Rebuilding Consumer Confidence in California Cantaloupe	
Grant Recipient: California Cantaloupe Advisory Board	**Grant Agreement No.:** SCB12020	**Date Submitted:** December 2015
Recipient Contact: Marilyn Dolan	**Telephone:** (831) 786-1665	**Email:** marilyn@tcdinc.org

Project Summary

A 2011 outbreak of listeria associated with cantaloupes produced on one farm in Colorado that resulted in the death of at least 30 people, understandably, impacted the confidence consumers have in buying and eating cantaloupes from any growing area. Over the past 20 years, the California Cantaloupe Advisory Board (CCAB) has invested significantly in research to enhance growing and packing practices that will ensure a safe product. California cantaloupes were not associated with the 2011 listeria outbreak, yet sales of all cantaloupes decreased regionally by up to 50% due to lack of consumer confidence. The California cantaloupe industry has continued to invest in preventing contamination of cantaloupe despite never having been associated with an outbreak. In 2013, the CCAB established a comprehensive food safety program to verify through mandatory third-party audits that all cantaloupes grown in the state have been produced under a set of science-based food safety practices. It is crucial that consumers learn about and understand this program because without assurances, consumer concerns will persist and purchases of cantaloupes will continue to decline. Through this Specialty Crop Block Grant Program (SCBGP) project, the CCAB was able to conduct an outreach campaign to (1) educate consumers on the industry's current food safety practices and (2) rebuild consumer confidence in California cantaloupes.

Market research showed that during the Colorado outbreak, 45% of consumers had stopped buying cantaloupe, with retailers reporting a 53% sales drop. Recovery of lost demand occurred over time, but it was critical to the long-term success of the California cantaloupe industry to re-establish consumer confidence in their product, particularly because California is responsible for the production of over 60% of all cantaloupe sold in the United States. The CCAB has invested significantly in the development of a mandatory food safety program; however, the grant funds were critical in conducting an education and outreach effort to inform consumers about the program and the efforts of the California cantaloupe industry to ensure consumers could be confident in the safety of cantaloupe from California, increase demand, and return sales to pre-outbreak levels.

The project does not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Previous to the grant period, the CCAB developed a website to communicate with the public about the food safety program and provide consumers with recipes, usage ideas, and other information on cantaloupe. As part of the grant, a number of social media channels were also established including a Facebook page, a Twitter account, and a YouTube channel. Over the course of the grant period, additional channels were added including Pinterest, Instagram, and Google+. These outreach tools would become the basis for communicating with consumers about important cantaloupe information including fun, attractive, and enticing recipes, as well as the secondary message on food safety efforts relating to cantaloupe.

Cooperating partners regularly engaged on these social media platforms sharing information, recipes, photos, and other consumer information on a constant basis throughout the grant period. This involved daily and weekly posting on all channels. New website content in the form of videos, recipes, photography and infographics were developed. Specifically, the grant funding allowed CCAB to create 27 new cantaloupe recipes and to have these professionally photographed and styled. Partners also created 13 videos that have been posted on YouTube and shared on social channels. These videos include cantaloupe subject matter ranging from farming and packing, food safety practices, proper handing at home, cutting and storage information, and recipe and usage tutorials.

To build a larger consumer audience, encourage engagement on social media platforms, and drive visits to the website where information on cantaloupe safety is available, a number of activities were sponsored through the grant. Over the course of the grant period, eight consumer promotions were conducted including consumer sweepstakes, informational quizzes, recipe contests, and surveys. Prizes were paid for with outside funds. All activities were designed to create interest in California cantaloupe and build the online audience.

Activities to analyze and measure the audience being developed were also conducted throughout the grant period. In addition, a special activity was conducted to measure consumer and media reaction during the pre-outbreak period and compare it to responses during and after the outbreak. The results from this activity were used to create a special “dark site” as part of the CCAB website which can be activated in the event of a future food borne illness event associated with cantaloupe. This site is now available to communicate important information to consumers and the trade in the event of an outbreak and to assist the CCAB in reaching consumers with information about the problem and what actions are being taken by California cantaloupe farmers to ensure consumer safety.

This project was focused solely on communications, outreach efforts, and information on California cantaloupes.

Initial social media channels were created by one of the project’s contractors under the direction of the primary project administrator. The contractor also developed videos which depicted cantaloupe growing, harvesting, packing, and food safety activities. This contractor also conducted the analysis of pre- and post-outbreak online conversations. In Year 2 of the project, all implementation and oversight of activities were assumed by the primary project administrator. These activities included all posting and engagement on social media channels, website content development (recipe development, video development and photography), internet promotions, message refinement, and measurement and analysis of results.

Goals and Outcomes Achieved

To achieve performance goals and outcomes, it was critical to develop engaging content that would interest consumers and regularly share the information on social media channels. The project goal was to return sales of cantaloupe to pre-outbreak levels at a minimum; however, because cantaloupe sales can vary widely from season to season, the primary measurement of success for this project was chosen to be the size of the consumer audience reached through social media tactics. In order to reach and maintain a large consumer audience, there were regular and constant posting on social channels. This activity was the most time-consuming of all activities, as devoted staff time was required to post on social channels each day. In addition, it was necessary to implement online promotions designed to reach out to a wider audience and encourage them to visit and engage within the social media channels of the CCAB. Only with relevant and engaging content and regular posting can an online audience be developed. It was also critical to analyze and measure the success of online activities throughout the grant period in order to help determine if the activities were achieving desired results and to determine which actions were working most effectively. Because of this, an analysis of the online audience was conducted on a monthly basis.

The long-term goal of this project was to ensure consumer confidence in California cantaloupe. Fortunately, there have been no major foodborne illness events associated with cantaloupe during the grant period. This makes it difficult to test whether the activities funded through the grant have been successful. However, there is no question the California cantaloupe industry prepared to respond to any future food safety event concerning cantaloupe in a much more effective way than ever before as a result of this grant project. The organization has an established website with a large consumer following and the ability to quickly reach out with important information to concerned consumers. This ability could not have existed without funding from this grant and these social media channels will be critical if there is ever a problem with the potential to disrupt cantaloupe sales in the future.

A key objective of this project was to reach a large database of consumers, media, and other public figures through social media sites. As a result of the grant, there is now a large and actively engaged audience on the social media sites created. These social media channels provide a platform to educate consumers about a number of cantaloupe topics, including food safety practices, and to rebuild consumer confidence in California cantaloupes.

The audience numbers generated through the campaign are in-line with expectations, but when it comes to reaching consumers, the audience can always be larger. What is most important is the level of engagement with this audience on a daily basis. The framework has been built to reach an audience of consumers who care about and are interested in cantaloupes. When and if a high-profile problem emerges concerning cantaloupe, there is no question that the audience built through this project will play a critical role in the ability to spread information widely on social media channels.

Because the social media channels did not exist before this grant project, the baseline for audience measurements is zero. Efforts through this project have allowed continuous expansion of the social media audience throughout the grant period and it is continuing to grow. Below is information on the size of the audience that has been developed to date for the social channels as well as information on average daily visits to its website and the number of people who are subscribing to CCAB's online newsletter.

	Followers
Facebook:	16,000
Twitter:	680
Instagram:	509
Pinterest:	449
Google+:	91
Website visits:	70/day
Newsletter subscribers:	3,500

The project worked well to build an online audience as noted above. The major accomplishment; however, was that the project did not just increase audience numbers, but the activities conducted worked to build an audience who is interested in and engaged in the information available online about cantaloupe. This factor, more than the audience size, will be important if a future foodborne illness issue presents itself. Performance measures show the audience developed does, in fact, regularly engage with the CCAB. Online responses clearly indicate this audience likes and is interested in cantaloupe and appears willing to recognize the efforts of farmers to produce a safe, healthy product. This is the kind of audience who would potentially become advocates for cantaloupes and cantaloupe safety if needed in the future.

As part of the ongoing analysis of the audience, the project regularly measured metrics to gauge the level of engagement the audience had with information presented by the CCAB. The number of times audience members engaged with social media posts were monitored closely. To be clear, an ‘engagement’ was defined as any time an audience member ‘liked’, ‘retweeted’, ‘followed’, ‘posted’, ‘shared’, ‘commented’, ‘clicked’, or otherwise interacted with a social media post, and also whenever they visited the CCAB website. The goal of the project was to achieve an engagement rate of between 12 and 15 percent. In actuality, during the last month of the grant project, the engagement rate was 18.9%. The engagement figures throughout the grant period have regularly exceeded targets.

Another very valuable result of the activities conducted was the development of a robust audience of people who subscribe to the CCAB’s e-newsletter. As part of the grant activities, CCAB has developed and regularly posts to a blog on its website. The blog is published twice per month and an e-newsletter is sent to subscribers each time a blog is posted, or if there is other newsworthy information to convey. The newsletter list was developed in conjunction with the online promotions conducted through the grant and grew from zero to 3,500 recipients during the grant project. This means that should the need occur to reach out to a consumer audience directly, there is an established base audience of 3,500 consumers who are interested in and could advocate for California cantaloupes. The newsletter is sent to subscribers through an e-mail service which allows the ability to track the number of times and who opens these e-newsletters. Overall, the newsletter is achieving an open rate of approximately 18%, which is above the industry average of 16%. The unsubscribe rate is also very low at 1.5%.

Analysis conducted shows that the CCAB website is ranking very high for some important key search terms on Google. This is the result of web content that is continually refreshed on the site and a number of other factors. Currently, the website is coming up on page one of Google search rankings for the following search words: cantaloupe, California cantaloupe, cantaloupe safety, and cantaloupe recipes. These are excellent results and mean that consumers looking for information on cantaloupe and cantaloupe safety will likely quickly find the CCAB website where they can learn about the safety measures in place. In addition, consumers searching for recipes will be exposed to the food safety messaging should they visit the CCAB website as a result of their search.

Beneficiaries

Members of the California cantaloupe industry have benefitted from the social media outreach program developed through this grant project, primarily because there is now a means to reach consumers directly with important information in a food safety situation that could impact cantaloupe sales. No longer do cantaloupe farmers need to rely solely on the news media to communicate information with consumers. In addition, there is a benefit to consumers who will also have direct access to facts and information about which cantaloupes are safe to eat and those that may not be when and if this becomes necessary. This creates confidence in the safety of cantaloupes.

The stated beneficiaries of this project include over 100 growers and 35 handlers of California cantaloupe that produce 20 - 25 million cartons or 60 percent of world-wide production each year. This project has also benefitted the sales and marketing teams of these 35 handlers who communicate with their customers and can utilize the CCAB social media channels to provide information to their customers about the California cantaloupe industry's comprehensive food safety program of which they are members. It is the hope that, in the event of a future outbreak, this system would prevent the sales losses for California cantaloupe farmers. It is estimated that as a result of the 2011 listeria outbreak, 760,000 cartons of cantaloupe were either dumped or not harvested because of lack of consumer demand. At an estimated average free on board (FOB) price of $6.00 per carton, this loss represents a shortfall of $4.5 million. This is what the CCAB hopes to reduce or eliminate in the future.

Lessons Learned

In the early stages of the project, project staff assumed that the goal would be create as large a consumer audience as possible. However, project staff quickly learned that it is very easy and inexpensive to generate a large number of fans or followers on social channels like Facebook. However, often these actions draw a large audience who is not, and never will be, interested in cantaloupe or food safety. The CCAB quickly realized it would be much more beneficial to have a smaller, but more engaged audience, rather than having large numbers of followers who may never be interested in cantaloupe. As a result, the strategy used to build the online audience evolved and changed through the campaign to accommodate project objectives. As is demonstrated above, the results have been to create a smaller, but very engaged audience. The CCAB believes this audience will prove much more beneficial to them than a larger, less engaged audience.

Project staff did not set out in the beginning to develop an e-newsletter list; however, it was quickly realized that the online promotions conducted through project activities provided access to a large numbers of consumer e-mails. It was very easy to keep this audience engaged by proactively distributing the CCAB blog through a regular e-newsletter. This e-newsletter has become one of the best results of the project because it provides a way to reach consumers directly via e-mail.

Significant results were achieved through this project and the CCAB Board has expressed that it is pleased with what the project has accomplished.

Additional Information

Links to the CCAB website and social media channels are below.

Website = www.californiacantaloupes.com
Facebook = https://www.facebook.com/Calcantaloupes
Twitter = https://twitter.com/CALCANTALOUPES
YouTube = https://www.youtube.com/user/CaliCantaloupes
Instagram = https://instagram.com/calcantaloupes
Pinterest = https://www.pinterest.com/calcantaloupes/
Google+ = https://plus.google.com/+CaliforniacantaloupesAB/videos

USDA Project No.: 21	Project Title: Building Markets for California's Fastest Growing Specialty Crop Industry	
Grant Recipient: California Olive Oil council (COOC)	**Grant Agreement No.:** SCB12021	**Date Submitted:** December 2014
Recipient Contact: Patricia Darragh	**Telephone:** 888-718-9830	**Email:** oliveoil@cooc.com

Project Summary

The initial purpose of the grant proposal was to educate consumers and retailers as well as provide information to California producers so that they could enhance their knowledge of olive oil which would result in increased sales for the fastest growing specialty crop in the state. The strategy was to focus on two regions of the United States. The two regions were the state of California, and the Mid-Atlantic region, which were determined to be receptive to a California grown quality product. The strategy was to focus on these key regions by providing outreach to chefs, food professionals, retailers, consumers, and media. Additionally, the California Olive Oil Council (COOC) was committed to educating its members on social media techniques and methods to increase their success. Part of the objective was to attain 5 % of the market share in the United States in 2015, up from less than 2 % in 2012. As of the end of the third quarter 2014, the California market share is almost 4 %. The project team is confident by 2015; this will reflect the goal of 5 %.

The time frame for this project was critical because in 2012, the California olive oil industry was facing a dramatic increase in production and major challenges form the import market. This project did not build on a previous SCBGP project.

Project Approach

This grant allowed the COOC, which represents more than 90 % of the olive oil production in the state, to realize a myriad of projects and programs to enhance the competiveness of California olive oil. Some of the project highlights were:

- The launch of a brand new website with a modern content management system. This allowed the COOC to greatly expand the content and images, which resulted in doubling the information available from the site. Added value to consumer and producers were educational materials, events page, "meet a farmer" and other sections. The website is accessible at http://cooc.com/
- Upgraded marketing and educational materials. Expanded educational materials to include what is extra virgin olive oil, sensory 101 and recipe cards. The COOC brochure was also revised and images were upgraded. Both the upgrade and expansion allowed for over 30,000 pieces of educational materials to be disseminated to the target group in the two-year period October 2012-October 2014.
- The COOC exhibited at a number of show and conferences including the Specialty Food shows in New York and San Francisco (formerly the NASFT shows), the Produce Marketing

Association show in Anaheim, the Natural Products expo in both Baltimore and Anaheim and other venues.

- In addition to these major shows, the COOC was able to reach out to smaller audiences in the targeted areas such as the Herb Society of America, Artisan Market-Los Angeles, the California Food Technologists conference, Sister to Sister in Washington DC (women's heart health) and others.
- The COOC provided educational forums to members on diverse subjects such as social media, branding, packaging and labeling, distribution channels, brand identity, health benefits, blending techniques and sensory.
- In an effort to increase retail support and knowledge, the COOC participated in a number of awareness events that provided unique education to retailers in the targeted regions.
- Media dinners create consumer awareness and information about the California olive oil industry for the benefit of solely enhancing specialty crops. It is through events such as the media dinners that incorporate olive oil with both a fresh and farm theme that many demographics of consumers are reached. The dinners provide demonstrations on how to make food with California extra virgin olive oil, and have been a huge success in cities such as New York, Baltimore, La Jolla and San Francisco to further help create awareness of a local California specialty crop with the help of media coverage.
- Launched new logo to replace the old one that had been in use since the 1990's. The new logo provides a clean, modern and fresh approach, which mirrors the COOC marketing strategies.
- A major focus was building a market while building partnerships. This project has been very successful with companies and organizations such as We Olive, Cal-Expo, Williams-Sonoma, Good Food Awards, Olive Center-UC Davis and others.
- The COOC continued to highlight and market California olive oils in a wide marketplace. Additionally, COOC formed a partnership with Williams-Sonoma nationwide (225 stores) to provide educational materials and host an educational webinar for their entire retail staff and culinary specialists. The webinar was broadcast in August 2014 and the educational and marketing materials were available in July and August 2014. As a result of this success, Williams Sonoma will be adding two more COOC produced webinars nationwide for release in the first quarter of 2015 (The Health Benefits of Olive Oil and Baking With Olive Oil). The content will also be available for COOC members to be used in their individual promotions (to be released March 2015). This partnership resulted in a 140 % increase of California extra virgin olive oil placement in Williams-Sonoma stores nationwide.
- Advertisement in Edible magazines on both coasts as well as targeting ads in the Produce Management Association (PMA) publications.

Goals and Outcomes Achieved

The COOC was able to reach every goal with the exception of the retail/restaurant decal. While that is about halfway done with the design draft, the launch will not take place until 2015.

<u>From the Expected Measurable Outcomes Goal # 1</u>: As noted above, the diversity of events in a range of regions reaching a myriad of targeted segments was successful and long reaching. The goal was to capture 5 % market share by 2015, which the project team is very close to reaching since currently, it is

just under 4 % at the end 2014. With the release of IRI data in late January for 2014, the project team will know if the goal of 5 % was reached by year-end 2014.

From the Expected Measurable Outcomes Goal # 2: Noted below is the information for the goal: Maintain price premiums of at least 40 % over the average selling price of imported olive oils in the same regions:

Example of Northern California brands: Average price of imported oils such as Felipe Berrio, Carapelli and Star: $ 9.01 per 500 ml (using stores such as Safeway, Lucky's and Nugget. In the same stores California Olive Ranch (the largest California producer, the lowest priced and the most widely distributed nationwide) sells for an average of $ 11.62 per 500 ml. This accounts for a price difference of $ 2.61 or a difference of 29 %.

Using the average price of some of the mid-range California produced extra virgin olive oils, the numbers are as follow:

Bari Olive Oil Deli Blend 500ml: $ 15.00

Calivirgin Oil Arbeqauina Blend 500 ml $ 28.00

Enzo Organic Olive Oil Delicate Blend 500 ml $ 18.00

Average Price $ 20.33

Difference between imported supermarket brand and the above mid-range is $ 11.32 or 126 %.

Based on the above scales and considering the fact that there are also California oils produced in the $ 42-45 per 500 ml range, it is believed that the overall premium % would be 55-65 % minimally.

From the Expected Measurable Outcomes Goal # 3: The total number of key industry influencers, such as chefs, food writers, bloggers, media press, who are helping this project goal by creating consumer awareness and attention to California olive oil for the purposes of increased purchases and exposure were contacted during the project period October 2012-October 2014 and reached 5,864 people.

The project allowed the COOC, to the benefit of its statewide members, to address many of the marketing and educational needs. In fact, the project allowed the COOC to reach out to over 10,000 consumers, retailers, chefs and other culinary professional in this two-year period and countless more via educational materials, website and other outreach programs.

Expected Measurable Outcome Goal # 4: Increase unique website visits from a benchmark of 1,000 per month to a target of 20,000 (annum) by November 2014.

Average # of unique visits per month prior up to October 2012: 1,000

Average # of hits during website expansion period November 2012-March 2013: 1,730 hits

Launch of new website April, 2013: Average # of unique visits per month beginning with launch month, April 2013 through November 2014: 2,969 visits. This represents an average increase of 1,239 additional unique visits per month, a 71.6 % increase from the pre-launch period of April 2013 or an average of 35,628 visits per annum. The Goal was 20,000 visits, and COOC exceeded that goal.

Beneficiaries

The project benefitted California olive oil producers. There has been a marked increase in the share of California grown olive oil in the last two years. Since 2012, 11 new milling operations have been established and 4 have increased their facility size. In some cases, olive oil companies have increased their staff size by 50 % or more. Not one producer in the state with production under 500 gallons has closed down since 2012.

Lessons Learned

1. It was determined that the most successful endeavors were person to person. Ad placement was not as successful as hands on outreach.
2. Strategy and success must be reviewed every quarter in order to view and change the strategy as necessary in order to achieve goals.

Additional Information

- Attachment 1: The California Extra Virgin Olive Oil Certified Seal
- Attachment 2: Educational materials

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 22	**Project Title:** American Pistachio Growers New Product Research	
Grant Recipient: American Pistachio Growers	**Grant Agreement No.:** SCB12022	**Date Submitted:** December 2013
Recipient Contact: Alec Wasson	**Telephone:** 831-661-0167	**Email:** aw@wassonideafarming.com

Project Summary

Pistachios have experienced tremendous growth since large-scale production began in the late 1970s and now stand as one of California's top ten agricultural exports. The problem is that in 2010, the pistachio crop was 48% larger than estimates had predicted, and as a result, the industry experienced its largest carryover of unsold product. Furthermore, current estimates show that production is expected to double by 2017 and reach one billion pounds. In order to ensure viable demand and offset this tremendous increase in supply, additional uses beyond the traditional in-shell snack market must be uncovered. This project worked to identify new pistachio product opportunities through in-depth consumer research. The pistachio industry was already investing in the development of prototype new products through work carried out by California State University, Fresno and Cal Poly, San Luis Obispo, but was unsure if they met the needs of consumers. The goal of this project was to help American Pistachio Growers identify new products that meet consumer demand and would have the best chance of being embraced by food manufacturers.

Pistachios have been one of the fastest growing specialty crops in recent years. With a clear path for new product development, this growth will continue benefiting growers, processors, and industry partners as well as the communities in which they are based. California produces 99% of all American grown pistachios, representing over $672 million in business activity to the California economy in 2011 and stand as the state’s sixth largest agricultural export. Today's pistachio farm gate value in the U.S. is estimated at almost $1.1 billion and the industry creates 5,820 jobs in California alone. Between 2006 and 2012, pistachio production grew from 237 million pounds to 555 million pounds. However, the industry’s strong growth also stands as a major threat. Production is expected to double by 2017 due to increasing acreages and better yields. In fact, over 25% of total pistachio acreage in California is still considered "non bearing” and thousands of new acres are planted each year. In order to maintain profitability and price stability, new demand for pistachios must be created. For almost all other tree nuts, consumption is primarily through ingredient-based uses. However, eighty percent of all pistachios are consumed as a snack nut. By identifying new consumer products that utilize pistachios as an ingredient, this project takes an important step towards creating additional market demand. It is an essential part of keeping the industry moving forward and will have a direct impact on the thousands of people who rely on the pistachio industry for jobs as well as on California’s economy as a whole.

Project Approach

The project was first introduced to a group of students at a local culinary institute, which led to an informal focus group where prospective products were brainstormed and debated. The classroom of future chefs helped create over 50 product ideas.

Building on the first session, a think tank of food specialists was held with the objective of creating and evaluating a comprehensive list of potential products. This group was a diverse mix of creative minds that included culinary students, chefs, mothers, food service representatives, nut retailers, agricultural representatives as well as APG's senior leadership. Together, they brainstormed and created 100 possible product ideas before debate zeroed in on the top 10-15 most promising concepts. The direction provided by APG allowed the group to not only think creatively, but also utilize their knowledge as to which items would make the most sense from a food manufacturer's point of view. Some ideas were ruled out early as they wouldn't use a significant amount of pistachios, and therefore would not help with the project's goal of increasing demand for the product.

Following this meeting, a product report and idea boards were created for use during the quantitative and qualitative testing. Bids from various research firms were solicited and analyzed before an agency was selected and questionnaires were reviewed and finalized. Once the format for the focus groups was set, recruitment began and participants were carefully screened based on their demographics. Finally, 3 online focus group sessions were held and the findings were analyzed along with the results from a qualitative online survey.

Overall, the research overwhelmingly showed that people like pistachios and would be interested in seeing more products featuring them as an ingredient. The Top 5 products identified were: pasta, pesto, bars, crackers and inclusions. One surprising finding was that there seemed to be a negative correlation between how unique a product was and how interested the respondents were in trying it. Items like pistachio milk and pistachio hummus did not perform well as people viewed these as too unique. The most popular items were also perceived as less unique.

The results of the project were compiled into a report as consumer research for food manufacturers and presented to them during the 2013 Institute of Food Technologists Expo in Chicago. Pre-show, the Project Manager coordinated with APG to set up meetings with various food manufacturers that had been specifically targeted based on the type of products they offered. The team also reviewed and finalized the development of handouts and binders to be used at the Expo. During the show, meetings were held with both attendees and exhibitors and the Project Manager provided information as requested by various manufacturers about the pistachio consumer research. Any trade leads were referred directly to APG for follow up.

Goals and Outcomes Achieved

The expected measurable outcomes for this project were to identify four new product opportunities through extensive consumer research and present them to both pistachio processors and food manufacturers. This comprehensive research will be a great asset as the pistachio industry moves forward in trying to help manufacturers commercialize and market new products featuring the nuts. Consumer research showing strong interest in new pistachio products helps strengthen the case for increased use as an ingredient. The concepts developed through this project show strong consumer interest and will hopefully pique the interest of food manufacturers, who will in turn create new demand for an additional 25-30 million pounds of California pistachios. In order to track and quantify this increase demand, APG is committed to tracking monthly shipment reports for pistachio kernels, which are used primarily by food manufacturers. Already, the industry has seen tangible positive results from this project. Since the IFT presentations in July, domestic kernel shipments have totaled almost 6.1 million pounds, a 30% increase as compared to the same three month period in 2012.

Through the online quantitative research, brainstorming sessions, and focus groups, findings clearly showed that people were interested in, and even more importantly, eager to purchase new products featuring pistachios. The information presented to manufacturers has already begun to bear fruit as they work to develop and test new pistachio product offerings. A popular response during the meetings at IFT was that this information was very timely, as many companies are exploring new gluten free options that could incorporate pistachios as a featured ingredient.

APG will handle the next steps and move forward to work with manufacturers during the product development process. Already, one major manufacturer has requested samples of pistachio meal/flour to be sent to research labs as the base for a possible new line of pistachio pasta. Several others requested follow up meetings to learn more about the various forms of pistachios that are available.

Beneficiaries

This project will help facilitate future product development initiatives by food manufacturers and will have a significant impact on growers, processors, and other industry partners who rely on an economically healthy pistachio industry. With pistachios representing over $672 million in business activity to California and ranking as the state's sixth largest agricultural export, even a small increase in demand will have a massive impact. Today's pistachio farm gate value in the U.S. is estimated at almost $1.1 billion and the industry creates over 5,820 jobs in California alone. The benefit of keeping this market strong by proactively creating new demand ahead of supply will help ensure a prosperous future for this important California specialty crop.

Lessons Learned

One major insight obtained through this project is that there is a strong consumer interest for new products featuring pistachio. As the industry continues to grow, it is clear that there are eager customers ready to purchase pistachios in new forms beyond the traditional in-shell snack. This information helps diffuse some of the concerns that arise along with the forecasted increased production.

Another insight was that uniqueness did not necessary translate into consumer demand. Rather, research showed that people generally indicated the more unique a product was, the less likely they were to purchase it. In this case, familiarity with a product seemed to increase consumer's willingness to try the product. As a result, the pistachio industry has been able to narrow down the scope of its product development activities in order to maximize the chances that new products reach commercialization.

Regarding the budget for this project, during the process of gathering quotes for consumer research, bids were consistently coming back higher than initially planned. In order to meet the budget requirements, it was decided that using virtual focus groups would be more cost effective than traveling to host in person meetings. At the same time, the virtual focus groups allowed the researchers to reach more people in a shorter period of time. This change allowed for additional funds to be used in creating presentation materials and reports for the meetings with food manufacturers at IFT.

Additional Information

See attached for pistachio concepts, discussion guide, questionaire, and report.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 23	**Project Title:** VeggieRx	
Grant Recipient: Fresh Approach	**Grant Agreement No.:** SCB12023	**Date Submitted:** December 2015
Recipient Contact: Leah Smith	**Telephone:** (925) 771-2912	**Email:** leahsmith@freshapproach.org

Project Summary

VeggieRx was developed in response to two significant needs: 1) the need to reverse the alarming trend of increased diet-related diseases, particularly among low-income populations, by connecting health care services and their clients with nutrition education and food access programs, and 2) the need to support the economic viability of California specialty crop producers by increasing their sales and consumer base.

Diet-related diseases are prevalent among low income populations. Significant barriers prevent lower income populations from consuming sufficient quantities and an adequate diversity of fruits and vegetables. These barriers include lack of access (significant distance from home to healthy food, and often lack of transportation), lack of income (inability to afford healthier choices), and lack of nutrition knowledge.

Adult data from the 2014 California Health Interview Survey (CHIS 2014), conducted by the UCLA Center for Health Policy Research revealed that 28% of Bay Area adults live at or below 200% of the Federal Poverty Limit (FPL) and they are 42% more likely to be overweight or obese and 33% more likely to have ever been diagnosed with diabetes than those living above 200% FPL. Low income populations are more likely to be food insecure, meaning they lack reliable access to a sufficient quantity of affordable, nutritious food – in the Bay Area, 37.9% of those living at or below 200% FPL are food insecure (CHIS 2014). These vulnerable populations often lack basic cooking skills and nutrition knowledge to make informed choices. The basic ingredients for health are clear and well-studied: A diet with a variety of fruits and vegetables can treat heart disease, promote weight loss, and prevent diabetes and cancers. Despite this, low income populations only consumed 18% of the recommended dark green vegetables compared to 33% for the higher income group, a trend that was consistent among other types of fruits and vegetables (USDA-ERS data 2007-2010).

In California, those at or below 200% of Federal Poverty Level spend $21 billion on food each year with the majority spent on processed and packaged foods. If a larger portion of the $21 billion were spent on fruits and vegetables, low income individuals would improve their health and lower their healthcare costs. A recent University of Southern California study showed increased vegetable consumption, as small as an additional half serving per day, can lead to dramatic health benefits (Cook, L., O'Reilly, G., et al. 2014. Vegetable Consumption Is Linked to Decreased Visceral and Liver Fat and Improved Insulin Resistance in Overweight Latino Youth. *Journal of the Academy of Nutrition and Dietetics, 114(11),* 1776-83. doi: http://dx.doi.org/10.1016/j.jand.2014.01.017. If people of low-income select locally-grown produce, they also boost the local economy and sustain California's specialty crop industry.

Fresh Approach's VeggieRx program connects community-based health clinics and community centers serving low income populations at-risk of diet-related diseases, with nearby farmers' markets that sell fresh California-grown specialty crops. Not only do people of low income benefit from utilizing California certified farmers' markets, many of which accept CalFresh/SNAP benefits and WIC, near where they live and work, but California specialty crop producers gain additional sales. Low income populations represent a potential growth market for California's specialty crop farmers who grow fresh fruits and vegetables and can provide much needed nutritious food to communities where it is greatly needed.

VeggieRx helps low income program participants, over the course of 16 weeks, understand the importance of eating specialty crops; learn techniques to select, store, and cook with specialty crops; and decrease the financial barriers to accessing specialty crops. Fresh Approach implemented VeggieRx by coordinating and tracking activities to meet two key objectives:

- Increase immediate purchases of specialty crop products at farmers' markets among low income populations and encourage their ongoing purchases of specialty crops
- Improve health indicators among low income populations by increasing their consumption of specialty crops

This project was and continues to be timely due to the accelerating trends seen across both the United States, as well as in California specifically, namely the increasing incidence of diet-related health diseases and obesity, particularly among low income Californians. Through the longer-term multiple and concurrent interventions that VeggieRx provides, there are significant changes in participants' health and eating habits. By including people of low income in the California certified farmers' market community, a winning public health solution that mutually benefits California specialty crop producers and program participants is created.

This project did not build on a previous Specialty Crop Block Grant Program project.

Project Approach

Fresh Approach commenced its VeggieRx programming in October 2012 and completed its objectives in June 2015. The activities of this project centered on providing a 16-week nutrition education, weight loss, and behavior change program to low income residents in San Francisco Bay Area communities. The basic program design included eight nutrition education class sessions where participants engaged in lessons, group discussions, and hands-on activities on important nutrition topics that aimed to encourage participants to eat more fruits and vegetables, less highly processed foods, and to prepare more of their meals at home. At each class session different recipes and cooking methods were demonstrated to encourage participants to begin preparing more meals at home. Classes also included information about specialty crops, how to prepare healthy meals on a budget using them, and which certified farmers' markets participants could find fruits and vegetables at in their communities. Participants completed a height and weight measurement each class, received weight loss coaching, and set their own goals to motivate healthy changes in their behaviors. At the end of each class session, participants received vouchers to spend on specialty crops at local certified farmers' markets.

The specific activities of this project involved partnering with seven different community-based health clinics (Gardner Family Health Network's St. James Pediatric Clinic, Indian Health Center of Santa Clara Valley, La Clinica Vallejo Medical Center, LifeLong Medical Care's Brookside Richmond Clinic and Dr. Jenkin's Pediatric Center, Native American Health Center – 7D Oakland, and St. Anthony's Medical Center – San Francisco) and two community centers (Nevin Community Center – Richmond, and Hamilton Recreation Center – San Francisco) to host VeggieRx programming. Memorandums of Understanding (MOUs) were signed with all clinic and community center partners, with three different farmers' market operators (Pacific Coast Farmers' Market Association, Fruitvale Farmers' Market, and Heart of the City Farmers' Market) to accept the VeggieRx vouchers, and with an evaluation specialist to aid in the development of assessment tools and third party analysis of program data.

Programming was coordinated with clinics and community centers to develop nutrition education curriculum and materials that were linguistically and culturally appropriate for each location. When programming was conducted in partnership with a community-based health center, participants were recruited from their patient population and clinic staff provided local support to participants during the programming. Support from clinic staff involved recruitment, conducting reminder calls for classes the day prior to the class and make-up visits when participants missed a class. Clinic partners also reviewed curriculum and class materials – giving feedback to expand content on some topics and approving materials for appropriateness for their patients. When programming was conducted in partnership with a community center, it was due to a need presented in the community for programming but no local community-based health center that had space on-site to host the classes. In community center partnerships, support from the center's staff involved providing classroom space and setting up spaces for Fresh Approach staff to conduct class activities, as well as answering questions about the program from the community on days when classes were not in session. Programs run in partnership with community centers recruited participants from the community center itself as well as nearby community-based health centers and other community-based organizations; included screening events run by Fresh Approach staff to determine participant eligibility; and had reminder calls and make-up visits conducted by the Nutrition Educator and/or Project Manager.

Across the community-based health centers and community centers where VeggieRx programming was held, 18 VeggieRx class series were conducted, each with eight class sessions – completing a total of 144 class visits where nutrition education, monitoring of health indicators, and farmers' market voucher disbursement took place. Due to staff constraints at project partner sites, all eight class sessions were conducted by Fresh Approach staff. Series of classes were grouped into rounds, such that two to five series of classes were conducted at different sites during the same months in any given year of programming. This allowed Fresh Approach staff to be more efficient with their allotted staff time and conduct more programming than initially planned in the approved work plan. Over the 18 series of VeggieRx programming 403 participants enrolled in the program and 320 completed the program by attending six or more class sessions. These participants received a combined total of over 100,000 pages of outreach materials that contained information on local nutrition and healthy food access resources and the information covered in each class session.

The Evaluation Consultant conducted seven focus groups over the course of programming that all took place after the final class session conducted by Fresh Approach staff, and presented reports to Fresh Approach staff on focus group results at the end of each round of focus groups. This immediate feedback from VeggieRx participants allowed the Project Manager and Nutrition Educators to incorporate feedback and suggestions into the following round of programming. Health indicators and pre- and post-behavior change assessments were gathered by the Project Manager at the conclusion of programming years and analyzed by the Evaluation Consultant. Fresh Approach staff also collected one-year follow-up health data and behavior assessments with all VeggieRx participants that completed six or more class sessions. The Evaluation Consultant compiled all sets of data and analysis into reports for Fresh Approach. Fresh Approach staff disseminated the evaluation results to stakeholders, clinic and community center project partners, program participants, and other interested parties via VeggieRx Convenings held in December 2013 and March 2015, and at the Slow Food San Francisco Childhood Obesity Conference held in March 2015. Results and reports are also available to the public on the Fresh Approach website (http://freshapproach.org/veggie-rx/).

This project had a significant impact on the more than 150 specialty crop producers who redeemed VeggieRx vouchers at local certified farmers' markets, bringing a total of $142,265 worth of income directly to California specialty crop producers – more than 36% of the total budget for this project. This project also produced significant results for the individuals and households involved in the direct VeggieRx programming. 47% of VeggieRx participants lost weight and improved their health over the course of the program, and another 15% sustained their weight with no significant increases during their participation in VeggieRx. These community members also gained a great deal of new knowledge and skills as a result of their participation in VeggieRx, with 99% reporting a better understanding of the importance of specialty crops, gaining skills in cooking with specialty crops, storing specialty crops, and shopping for specialty crops on a budget at the conclusion of the VeggieRx program. The individual and household successes seen during the course of the 16-week program translated into long-term health and behavior changes for participants. At follow-up visits conducted 14-19 months after the final VeggieRx class sessions, 75% of VeggieRx participants indicated they remain regular purchasers and consumers of specialty crops, 53% indicated they remain regular shoppers at local certified farmers' markets, 33% continued to lose weight and improve their BMI one-year or more after active programming, and 29% maintained the health improvements they made to their weight and BMI during active VeggieRx programming with no significant gains at the follow-up visit.

The significant results from this project led Fresh Approach staff and outside evaluators to conclude that the program is highly effective and meaningful in tackling nutrition and healthy food access issues faced by low income communities. Fresh Approach's VeggieRx program has been cited in two important reports on healthy food access in the Bay Area: SPUR's Healthy Food Within Reach report, and a report written for the San Francisco Food Security Task Force on Healthy Food Supplement Programs. Citations for these reports are available at the end of this report. The conclusion of these reports and Fresh Approach's evaluation of the VeggieRx program indicate that the program will continue to be deeply impactful for the households who are able to engage in the programming, the specialty crop producers who benefit from the creation of new customers, and the surrounding communities who are supported by the increased knowledge, skills, and economic impacts of the VeggieRx program.

The overall scope of this project only benefitted California specialty crop farmers and did not benefit non-specialty crops in any way. Staff ensured that funds were used to solely enhance the competitiveness of specialty crops by discussing specialty crops and the importance of supporting local farms at each nutrition education class session, conducting cooking demonstrations in each nutrition education class that were based on specialty crops and highlighted the nutritional benefits of eating specialty crops, and providing vouchers for program participants that could only be spent on fruits and vegetables at local farmers' markets. The produce purchased for each class session was purchased at a Pacific Coast Farmers' Market Association (PCFMA) farmers' market with tracking forms that allow the Project Director and Project Manager to know exactly what produce was purchased and from which farm. Supplemental supplies for cooking demonstrations, such as olive oil, were purchased from local grocery stores only to aid in the preparation of specialty crops. VeggieRx vouchers clearly state that they can be used only to purchase fresh fruits and vegetables, which are specialty crops. In addition, the vouchers can only be spent at participating farmers' markets so the specialty crops are purchased directly from California farmers. Finally, the vouchers redeemed are tracked using barcodes to know which farm received the vouchers, what types of specialty crops that farm sells, and what market and date the vouchers were redeemed.

Project partners' contributions to this project were instrumental in the success of the VeggieRx program. Clinic partners reviewed and provided critical feedback on the curriculum, class handouts, community resource materials, and pre- and post-surveys, which were reviewed for accuracy and style of presentation. Clinic partners also gave continuous feedback and suggestions throughout programming at their sites and between sessions during regular communication and meetings with the Project Manager and Nutrition Educators. Community center partners reviewed and added additional information to community resource materials and provided a local link for class participants or those interested in VeggieRx to connect with when class was not in session.

Evaluation specialists provided critical feedback and guidance for Fresh Approach staff in the creation of survey instruments and protocols, and aided in the collection and reporting of program data. The third party evaluators engaged in this project were crucial to the creation and maintenance of program data integrity.

Goals and Outcomes Achieved

When programming was conducted in partnership with community-based health centers, the Project Manager worked with clinic partners to recruit participants. Clinic partners would recruit participants from their patients whose BMI classified them as overweight or obese, and/or whose medical history indicated an elevated risk for diabetes. When programming was conducted in partnership with community centers, the Project Manager and Nutrition Educators would recruit participants from nearby community-based organizations and community-based health centers, and then hold a screening event at the community center where all those interested in the program were given more detailed information on VeggieRx, and were screened for income eligibility and BMI status. The recruitment process and pre-surveys completed with participants at the first class session determined baseline levels of health and behaviors.

At each class session, Fresh Approach and/or clinic partner staff took height and weight measurements to calculate BMI, or BMI percentile for youth participants, using standard medically approved measuring techniques. Some clinic partners also took blood pressure measures, however blood pressure was not collected by every partner site due to a minimal amount of clinic partner staff time or lack of proper equipment or training on site. During these measurement sessions, the program participant and the individual taking their measures spent 5-10 minutes discussing their weight loss and behavior change goals and progress. These measurement sessions provided the participant with added motivation and guidance on how to achieve their goals, and allowed Fresh Approach and/or clinic partner staff members to track physiological changes throughout the program.

At each class session Fresh Approach staff also distributed VeggieRx vouchers to program participants that could only be spent at local farmers' markets on fruits and vegetables. Each participant received $7 worth of VeggieRx vouchers per member of their household per week – so a family of four received $28 worth of vouchers, distributed in $2 amounts, each week of the 16-week program. Because class sessions were conducted every other week over the 16-week program, participants received vouchers enough for two weeks at each class session. Each program participant had a unique identification number in Fresh Approach's internal database that created a unique barcode for each voucher that was distributed to them over the course of the program. The barcode traced the year the voucher was distributed, the round of programming, the site where classes where conducted, the class number at the particular site (for instances where more than one class session was conducted at the same site in the same year and round of programming), and the individual participant number (e.g. Y13R1S02C01P206). Farmers' market partners redeemed VeggieRx vouchers at local farmers' markets and returned them to Fresh Approach staff with the date the voucher was redeemed, the farmers' market name/location, and the individual farm's name that redeemed that voucher. The combination of the unique barcodes and farmers' market data allowed Fresh Approach staff to track voucher redemptions to create a profile of participant's shopping habits and to correlate redemption data to individual health indicators.

Pre- and post-surveys for behavioral assessment were designed by the Independent Evaluator with feedback from the Project Manager. These surveys were completed by Fresh Approach staff in a health behavior interview format at the first and last class session. Data was analyzed by the Project Manager and Project Director to demonstrate changes to behaviors during the course of the program.

Seven focus groups were completed during the course of this project by the Independent Evaluator. Each focus group was conducted at the end of a series of classes and at least one occurring with participants in each round of programming. Focus group results were reported to Fresh Approach staff that then incorporated feedback and made changes to improve programming for participants. One-year follow-up protocols were completed with participants who completed six or more classes during the 2013 program year. Follow-ups included behavioral assessment surveys conducted over the phone or in-person and follow-up BMI measurements. This data was analyzed by the Independent Evaluator to determine the extent to which behavior changes and health indicators were sustained after active programming had concluded.

The activities described above resulted in the following measurable outcomes. This project benefited over 150 specialty crop farmers at 75 certified farmers' markets operated by the Pacific Coast Farmers' Market Association other farmers' market partners such as Heart of the City Farmers' Markets in San Francisco and Fruitvale Farmers' Market in Oakland. The beneficiaries were California farmers selling specialty crops at certified farmers' markets. In addition, across the seven community-based clinics and two community centers that served low-income communities, 1,505 low-income program participants and their household members benefited from increased access to, and consumption of, California specialty crops.

At the end of project implementation, specialty crop sales were directly increased by $142,265 in voucher sales. A large majority (99%) of VeggieRx participants better understood the importance of specialty crops and gained skills on cooking with specialty crops, storing specialty crops, and shopping for specialty crops on a budget compared to 54% of VeggieRx participants who reported the same level of skills and knowledge before the program. This represents an improvement of 83% at the conclusion of programming. These activities were tracked by comparing the prescreening tool to the post-assessment tool, and by using a retrospective post-test design recommended by the Independent Evaluator. At the end of VeggieRx programming 47% of VeggieRx participants improved health indicators such as weight and BMI and an additional 15% sustained their weight with no significant weight gain. Health indicators improved by an average of 3%. This number was tracked by Fresh Approach staff and/or clinic partners that measured health indicators eight times during the 16-week project implementation. Fourteen to 19 months after each active cohort completion, 75% of VeggieRx participants indicated they remain regular purchasers and consumers of specialty crops, 53% indicated they remain regular shoppers at local farmers' markets, 33% continued to lose weight and improve their BMI one-year or more after active programming, and 29% maintained the health improvements they made to their weight and BMI during active VeggieRx programming with no significant gains at the follow-up visit. The follow-up data was assessed by follow-up behavioral survey results and follow-up height and weight measurements.

Additional follow-up procedures will be conducted with program participants from 2014 and 2015 programming years to add to the total data collected by Fresh Approach on the long term impacts of their VeggieRx program. This data will be collected using funds for Fresh Approach staff time outside of this project's funds.

The actual accomplishments in this reporting period matched quite closely with the goals established. Intervention Round 5 concluded programming in May 2015 that began in January 2015. Intervention Round 5 conducted VeggieRx programming with two class groups at two partner sites where 58 participants were recruited and 42 completed the VeggieRx programming. A total of 16 participants were dropped from Intervention Round 5 due to their lack of attendance at class sessions. Health indicators were collected at each of the 16 clinic visits in Intervention Round 5, and post-surveys were completed with all Intervention Round 5 participants present at the final VeggieRx class session. Through the families of the 42 participants who completed Intervention Round 5, a total of 164 individuals received benefits from the vouchers distributed. After the final class session of the Round 5 intervention groups in May 2015, one focus group was conducted at one of the partner sites by an Independent Evaluator and the feedback from that group will be incorporated into future VeggieRx programming.

The clinic visits in this reporting period saw project staff and clinic partners distribute approximately 10,550 pages of outreach materials to VeggieRx participants and their friends and family in attendance at the clinic visits.

Project partners gave valuable insights into each site's client population, how best to connect with participants at their site and motivate the participants to increase their fruit and vegetable consumption. These insights helped project staff to tailor lessons and recipes to class participants to increase the effectiveness and impact of lessons.

One-year follow-up procedures concluded in the previous reporting period although planned to conclude in this reporting period. All participants who completed VeggieRx programming in 2013 were compiled into lists based on the month programming was completed and at which partner site. Contacting the 137 participants from 2013 began with phone calls to participants to complete the follow-up survey over the phone, and then current height and weight measures were collected during follow-up clinic visits at the sites where 2013 programming was conducted. 85 participants from 2013 programming completed the follow-up survey, and 61 of those who completed the survey also completed the follow-up clinic visit. Complete follow-up data including follow-up surveys and follow-up height and weight measurements were collected from 61out of the total 137 participants who completed VeggieRx in 2013. Fresh Approach staff and the Independent Evaluator analyzed data collected in all programming completed in 2014 including the one-year follow-up data. These analyses were reported on the Fresh Approach website and disseminated to community partners at a convening on March 27, 2015. The convening was supported through a grant from a private funder.

Farmers' market vouchers were redeemed by partner farmers' markets within Pacific Coast Farmers' Market Association, Heart of the City Farmers' Market and Fruitvale Farmers' Market. Redemptions were tracked by Fresh Approach staff to connect voucher data with the data from participants who received the vouchers.

This project aimed to benefit 175 specialty crop farmers at 75 different partner farmers' markets in the San Francisco Bay Area. This project directly and measurably benefited 150 specialty crop farmers at 75 different farmers' markets in the Bay Area. It is worth noting that other specialty crop farmers may have benefitted from non-voucher purchases that were not tracked and correlated to the VeggieRx participants. Fresh Approach staff tracked the actual voucher redemption, but this does reflect that these same customers, for example, may have used their CalFresh-EBT/SNAP card to purchase specialty crops from other producers as well. This project also aimed to benefit 2,380 VeggieRx participants and their household members through the VeggieRx programming and vouchers provided for the whole household, however only measurably benefited 1,505 people through the participants and their households. The discrepancy between predicted and actual beneficiaries is due to some class groups having less than 30 participants, and the unpredictable nature of household sizes.

At the end of project implementation, this project directly increased the number of specialty crop sales by $142,265 in voucher sales – a few thousand dollars less than the estimated $148,000. This discrepancy is due to the smaller class groups and household sizes than predicted in the project design. This project exceeded the behavior change goals determined by post-surveys with 99% (compared to the aim of 75%) of VeggieRx participant's better understanding the importance of specialty crops and gaining skills on cooking with specialty crops, storing specialty crops, and shopping for specialty crops on a budget compared to 54% of VeggieRx participants who reported the same level of skills and knowledge before the program. This represents an improvement of 83% (compared to the aim of 30%) at the conclusion of programming.

At the end of the 16-week VeggieRx program, 47% of participants improved their health indicators (compared to the aim of 35%), and an additional 15% sustained their weight with no significant gains (compared to the aim of 30%). In total, 62% of VeggieRx participants improved or sustained their health indicators over the course of the program, compared to the total aim of 65%. Health indicators improved by an average of 3% compared to the aim of improving by an average of 15%.

Follow-up procedures proved difficult to complete with all VeggieRx participants. Instead of being scheduled for exactly three months after the final class of a series was completed, follow-ups were scheduled for 12 - 20 months after the final class. This required adjustments to the project timeline, which added flexibility allowing Fresh Approach staff to conduct interviews with past participants from several classes at the same time, and to schedule the interviews for weeks when staff was not actively teaching classes but instead was available to make calls and receive return calls from past participants. Many participants were lost to follow-up due to incorrect contact information determined when project staff attempted to call, email, or send a letter to 2013 participants. These challenges resulted in 62% of participants who completed VeggieRx in 2013 completing the follow-up survey, and 45% of participants completing both the follow-up survey and the follow-up clinic visit where their height and weight were measured. The Project Manager and Independent Evaluator expected that 65% of VeggieRx participants from 2013 would participate in the follow-up procedures. Although the actual percentages of participation achieved in the follow-up did not meet expectations, the percentages are still quite high for the length of the follow-up (one year) and the low-income communities served. Follow-up results exceeded the aims for this project with 75% of VeggieRx participants indicating they remained regular purchasers and consumers of specialty crops (compared to the aim of 40%), 53% indicating they remain regular shoppers at local farmers' markets, 33% continuing to lose weight and improve their BMI one-year or more after active programming, and 29% maintaining the health improvements they made to their weight and BMI during active VeggieRx programming with no significant gains at the follow-up visit. This project saw a total of 61% of participants maintain or improve their health indicators post-active programming, compared to the aim of 40%.

The major successful outcomes of this project were seen in the creation and maintenance of new customers for specialty crop farmers. This outcome can be seen in the voucher spending data with $142,265 in VeggieRx vouchers were spent on specialty crops during this project and an estimated $120,000 that was spent by the 2013 VeggieRx participants who purchased the same amount or more specialty crops (75%) and continued shopping farmers' markets (53%) one year after active participation in VeggieRx. Other major successful outcomes relate directly to the VeggieRx participants where 99% became more informed about the importance of specialty crops, how to select and store them, how to shop for them on a budget, and how to prepare and cook them at home. Participants also saw the benefits of their increased knowledge and skill set directly impact their health indicators with 47% improving their weight during the program and 15% sustaining their weight with no significant gains during the program. These percentages are quite impressive for a group of low income, chronically overweight or obese participants who simply attended nutrition classes, monitored their weight, and worked to eat more fruits and vegetables – but did not actively participate in regular physical activity as a part of the program.

Beneficiaries

California specialty crop farmers were one of the greatest beneficiaries of this project. More than 150 farms redeemed VeggieRx vouchers across 75 farmers' markets during this project term equaling a total of $142,265 in vouchers spent – more than 36% of the total budget for this project. Farmers built new customer relationships with the 320 VeggieRx participants; and in one-year follow-up assessments 53% of VeggieRx participants reported continuing to shop at farmers' markets for their fresh fruits and vegetables. This new customer base for California specialty crop farmers represents an estimated $120,000 that VeggieRx participants are spending with farmers long after they have completed the program and stopped receiving the vouchers.

Another group that greatly benefited from this project was the VeggieRx participants. On average, adult participants lost five pounds during the program, 33% continued to lose weight one-year after programming ended, and 29% maintained their weight in the year following active programming. These participants have changed the way they eat and improved their health, and, from focus group reports, are spreading the message to eat healthy and shop at farmers' markets to their family members, friends, and community.

The beneficiaries of this project include:

- Over 150 California specialty crop farmers were directly impacted by having $142,265 in vouchers spent on their produce at 75 different farmers' markets in the San Francisco Bay Area.
- 403 people participated in the VeggieRx program by attending at least one class session, and 320 completed programming by attending six or more class sessions.
- At one-year follow-up, 53% of VeggieRx participants reported continuing to shop at farmers' markets, representing an estimated $120,000 worth of new income for California specialty crop farmers. If these participants continue to purchase specialty crops at certified farmers' markets and/or bring their family members and friends, the potential economic impact of this program will continue to expand over time. It is common for people who become regular farmers' market shoppers to bring other people in their lives.

Lessons Learned

This project provided many opportunities for Fresh Approach staff to learn how best to implement the VeggieRx program and how to be most effective with VeggieRx participants during the course of the project. Early on, the Project Manager learned that the initial structure in the workplan for this project that had four classes taught by Fresh Approach staff, and four classes taught by project partner staff, would not be feasible under the current climate in community-based health centers in the area. With health centers having limited staff persons and time that they could devote to wellness programming, the Project Manager determined that all eight class sessions would be taught by Fresh Approach staff with clinic and community center staff providing support on-site during class sessions, and clinic center staff providing support recruiting participants, placing reminder calls, and conducting make-up sessions.

After each round of programming staff reviewed focus group results, weight and BMI change results, behavioral survey results, anecdotal feedback given by VeggieRx participants, and staff experiences with the participants and curriculum in the program. This review provided crucial feedback for program staff allowing the Project Manager and Nutrition Educators to make adjustments to curriculum and class activities to improve the experience of VeggieRx participants and effectiveness of programming.

Focus group results were given a heavy weight in program review periods since these were a place where participants felt free to be honest about what they liked and disliked about the program, and where independent evaluators could probe on questions for program staff that illuminated participant's experiences at farmers' markets and their use of the VeggieRx vouchers. The curriculum and hands-on activities in each round of programming were slightly different as participants expressed a desire for expanded information on some topics. Cooking demonstrations were enhanced in their length and depth of content over the years of programming because participants expressed a desire for more hands-on demonstrations teaching them how to use the new produce they were finding at the farmers' markets. Weight loss coaching was also tailored for each round of programming, and also each site, with more guidance provided in these individual sessions as the years of programming progressed and dependent on the desires of each individual participant.

Programming initially began very structured, with BMI measures taken only at the beginning or very end of class sessions in order that all participants could pay full attention and participate during class sessions. This transitioned to a practice where measures were taken by the Project Manager throughout the duration of the class sessions, with each measurement and weight loss coaching session lasting approximately five minutes per participant. This allowed the Nutrition Educator to conduct the class session and lead hands-on activities with the help of interns or volunteers, and provided extended class time so the Nutrition Educator could cover class content in more detail and include a longer cooking demonstration. Class participants also seemed to prefer this structure as it allowed people to leave immediately after class was over, instead of having to wait for their measurements to be taken.

Communities around the San Francisco Bay Area welcomed this project to their cities and neighborhoods, and finding partners to host programming proved relatively easy because the Project Manager was able to offer the program to potential partners as a package that would greatly benefit their patients and/or community members and involved little staff time on the part of the center. Clinic partners appreciated the ability to review program curriculum and offer suggestions without having to create anything new, and community centers enjoyed being able to offer the exciting program to their neighboring communities and have insight on the resources provided regarding their specific community.

As a result of implementing this project in communities across the Bay Area, the VeggieRx program gained quite a few inquiries from other community-based organizations around the state and country interested in starting a similar program. These inquiries allowed the Project Manager to discuss the program with people outside of the Bay Area and to begin thinking about the larger implications of this nutrition education and healthy food supplement program beyond the initial impacts the program could have on community members and VeggieRx participants.

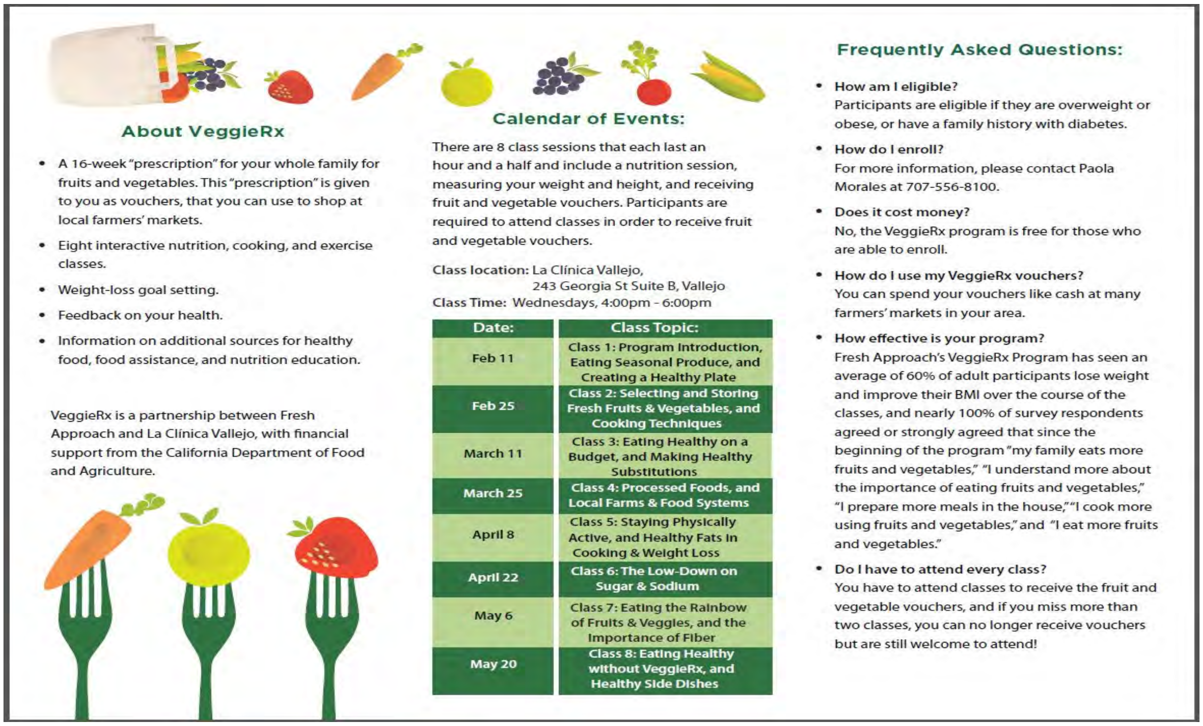
The outcome measure to benefit 175 different California specialty crop farmers was not achieved, and instead this project can confirm that it definitely and directly benefited 150 different specialty crop farmers. This is a small discrepancy, and a small percentage of VeggieRx vouchers were returned from partner farmers' markets without the name of the farm that redeemed the vouchers at the farmers' market. It is quite possible that the vouchers from this project did reach 175 different specialty crop farmers, but the small amount of missing data may be hiding that specific finding. In order to achieve this type of outcome in the future, Fresh Approach will hold their farmers' market partners to a higher standard of data collection.

Another outcome that was a bit below the aim was the total number of VeggieRx participants and their household members who benefited from the VeggieRx program and vouchers. Fresh Approach estimated a reach of 2,380, but actually only reached 1,505 community members through the class participants and vouchers that their household's received. The discrepancy between predicted and actual beneficiaries is due to some class groups having less than 30 participants, and the unpredictable nature of household sizes. Lastly, the outcome measures set for VeggieRx participant's health indicators were very close to being achieved with 62% improving or sustaining their health indicators during the program compared to the aim of 65%. Health indicators on average improved by 3% compared to the aim of 15%. The differences in the actual results versus those aimed for can be understood by the complexity and difficulty of changing individual behaviors, and by the reality that this project was a nutrition education and healthy food supplement program that did not actively engage participants in physical activity at each class session. The success rate of VeggieRx participants is quite high for a program that does not have participants doing physical activity at each class session. The aim that health indicators would improve by an average of 15% was a very hopeful aim set by Fresh Approach staff, but in retrospect was likely not a realistic goal. An improvement of this size would represent a participant who started the program weighing 250 pounds and lost 37.5 pounds over the course of the 16-week VeggieRx program. For the benefit of others learning from this project, Fresh Approach staff recommend developing a conservative estimate for participant numbers, and basing this on past experience with similar programs.

Additional Information

Fresh Approach's VeggieRx program was cited as a resource in two healthy food access reports published during the time of this project: SPUR's Healthy Food Within Reach report (http://www.spur.org/publications/spur-report/2015-02-05/healthy-food-within-reach), and a report written for the San Francisco Food Security Task Force on Healthy Food Supplement programs (https://www.sfdph.org/dph/files/mtgsGrps/FoodSecTaskFrc/docs/SFHealthyFoodSupplementProgram-updated.pdf). Fresh Approach has also published reports with quantitative data and focus group findings from this project on the organization's website (http://freshapproach.org/veggie-rx/).

Photographs from VeggieRx programming are below as well as examples of recruitment materials used in community centers and with clinic based programming.



About VeggieRx

- A 16-week "prescription" for your whole family for fruits and vegetables. This "prescription" is given to you as vouchers, that you can use to shop at local farmers' markets.
- Eight interactive nutrition, cooking, and exercise classes.
- Weight-loss goal setting.
- Feedback on your health.
- Information on additional sources for healthy food, food assistance, and nutrition education.

VeggieRx is a partnership between Fresh Approach and La Clínica Vallejo, with financial support from the California Department of Food and Agriculture.

Calendar of Events:

There are 8 class sessions that each last an hour and a half and include a nutrition session, measuring your weight and height, and receiving fruit and vegetable vouchers. Participants are required to attend classes in order to receive fruit and vegetable vouchers.

Class location: La Clínica Vallejo,
243 Georgia St Suite B, Vallejo
Class Time: Wednesdays, 4:00pm - 6:00pm

Date:	Class Topic:
Feb 11	Class 1: Program Introduction, Eating Seasonal Produce, and Creating a Healthy Plate
Feb 25	Class 2: Selecting and Storing Fresh Fruits & Vegetables, and Cooking Techniques
March 11	Class 3: Eating Healthy on a Budget, and Making Healthy Substitutions
March 25	Class 4: Processed Foods, and Local Farms & Food Systems
April 8	Class 5: Staying Physically Active, and Healthy Fats in Cooking & Weight Loss
April 22	Class 6: The Low-Down on Sugar & Sodium
May 6	Class 7: Eating the Rainbow of Fruits & Veggies, and the Importance of Fiber
May 20	Class 8: Eating Healthy without VeggieRx, and Healthy Side Dishes

Frequently Asked Questions:

- **How am I eligible?**
  Participants are eligible if they are overweight or obese, or have a family history with diabetes.
- **How do I enroll?**
  For more information, please contact Paola Morales at 707-556-8100.
- **Does it cost money?**
  No, the VeggieRx program is free for those who are able to enroll.
- **How do I use my VeggieRx vouchers?**
  You can spend your vouchers like cash at many farmers' markets in your area.
- **How effective is your program?**
  Fresh Approach's VeggieRx Program has seen an average of 60% of adult participants lose weight and improve their BMI over the course of the classes, and nearly 100% of survey respondents agreed or strongly agreed that since the beginning of the program "my family eats more fruits and vegetables," "I understand more about the importance of eating fruits and vegetables," "I prepare more meals in the house," "I cook more using fruits and vegetables," and "I eat more fruits and vegetables."
- **Do I have to attend every class?**
  You have to attend classes to receive the fruit and vegetable vouchers, and if you miss more than two classes, you can no longer receive vouchers but are still welcome to attend!

USDA Project No.: 24	Project Title: Yolo County Farm-to-School Planning and Implementation	
Grant Recipient: Yolo County Department of Agriculture	**Grant Agreement No.:** SCB12024	**Date Submitted:** December 2015
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Project Summary

Currently less than 10% of California's youth consumes the recommended daily servings of fruits and vegetables. Schools are seen as potential venues for offering healthful food choices to all the children, particularly those in lower income families. Yet, introducing fresh, locally grown produce from regional growers in school cafeterias is often challenging. With the nutritional changes in the National School Lunch program requiring that more fruits and vegetables be offered to kids in school cafeterias nationally, the Yolo County Farm-to-School Planning and Implementation grant focused on helping schools develop scratch cooking skills and menu options while simultaneously supporting California farms with strategies to meet the developing demand of local school procurement.

Effective school year 2012 to 2013, Federal law requires that schools procure more fresh fruits and vegetables for children, an opportunity for California specialty crops growers and regional farmers in Yolo County to benefit through targeted marketing, professional development, training, and procurement of fresh, seasonal produce in five Yolo County school districts and one countywide head start program. Additionally, the growing 'Farm to Fork' movement in the media has created more informed communities of parents who likewise demand product from local farms used in school meals. Combined, these elements provided possibilities for more local Farm to School Procurement.

This project does not build upon a previous Specialty Crop Block Grant Program funded project, nor has this project or any activities described in the proposal have been submitted to or funded by another Federal or State grant program. However, a previous 2010 Specialty Crop Block Grant Program Project 30: *Building Successful Farm to School Models to Enhance Markets for Specialty Crops* by another recipient influenced this project. The previous project worked with the Oakland, Winters, and Redding school district providing guidance and technical expertise for food service staff to sustain changes in procurement by learning how to cook with more fresh, regional products. The lessons learned in the 2010 project helped shape this project's pre-project programming ideas.

Project Approach

Objective one was to enhance Yolo County Food and Agriculture Website, maintain, and evaluate results. The website www.HarvestHubYolo.com was created to fulfill this objective and served two purposes: 1) disseminate information about the Yolo Farm to School Program and 2) create the online vendor marketplace for farms to sell specialty crops online, and for schools or other institutions to buy California Specialty Crops online. This website subsequently receives about 200 and plus active visitors daily. One of the lessons learned is that a farm directory product was more impactful than an online shopping tool. Built first, the online shopping tool required a lot of off-line relationship building and hand-holding to make the online sales tools happen, which ended up making the sales process more unwieldy. The project staff transitioned the online sales aspect into a directory concept with a listing of farms and product categories. This directory is now part of the Yolo County Food and Ag Website "www.HarvestHubYolo.com."

Objective two was to plan, conduct training and technical assistance for food service and farmers, and evaluate results. Project staff held a total of forty-five school food service trainings (three per year in each of the five school districts, over a three-year period for a total of forty-five trainings) focused on developing scratch cooking skills in school food service to begin working better with raw ingredients coming in whole form directly from local farms, defined as within 300 miles. Project staff learned that different school districts had varying levels of comfort with scratch cooking. Some jumped in and were excited to learn, others were slower to warm up to this concept. Another aspect was how receptive and engaged the school district leadership was to the classes. If they were more supportive, then the classes carried with them, "An air of festivity." Each school district carried its own 'personality' into the cooking classes. Availability of equipment and facilities was also a factor. Survey results revealed that learning new ways of handling food and ethnic flavor profiles for California specialty crops received positive feedback. However, the majority of staff reported that the recipes and foods, while interesting to the staff, struggled to be kid friendly. Another concern was whether or not the recipes met the School Nutrition Standards. This translated into interesting results: 1) Staff were happy to have professional development, but 2) The recipes were not used widely in school settings. Because the purpose of the classes was to raise the culinary acumen of the front line food staff, class attendees were also asked if they used any of the recipes or new California specialty crops at home. Overwhelmingly, the answer was "yes." The majority of respondents replied that they tried the new recipes and the new foods that they discovered in the cooking classes at home, and as a result, have changed their personal cooking routines.

This objective also called for the development of three farmer workshops incorporating school food service to define and overcome the obstacles to sales between school districts and farms. The first two workshops were panel and speaker formats and engaged a total of twelve regional farmers. The feedback from those first two events identified some key obstacles to purchasing: price, third party food safety certification, and uncertainty in the relationship between buyer and seller, they simply didn't know one another. This relationship barrier was revealed as the key that prevented sales. With that input in mind, project staff has constructed the third Farmer Training to focus on helping farms and schools get to know one another. Officially called the "Marketplace Exchange," this final training garnered sixteen farmers. Project staff used a 'speed dating' format to encourage the important 'meet and greet' followed by a relaxed reception where attendees could take their conversations further with those they were interested in making sales with. Each of the attendees received a stack of their profiles that they used to exchange with other attendees, so everyone left with contact information. From this event, 27% of farmers made sales that same day. Project staff also learned that the "Marketplace Exchange" was a good way to get relationships started. In following up afterward, it was discovered that these new relationships needed even more one-on-one support and translation services. From the date of the "Marketplace Exchange," it took between three to six months for School Nutrition Directors and Farms to restructure their buying and selling practices, and ultimately buy and sell from one another. After the "Marketplace Exchange," other farmer groups such as the Farm Academy at the Center for Land Based Learning, also wanted the information and trainings on how to do business with schools. Thus, project staff ultimately offered four trainings instead of three.

Objective three was to evaluate impacts of school procurement changes with more regional specialty crops.

The evaluation team at University of California, Davis in the Sustainable Agriculture Research and Education program, worked specifically with the food systems program. This evaluation team gathered baseline data on the use of California specialty crops in all five individual school districts. They discovered that on average, all school districts in Yolo County procured about 12-15% of their total produce from local sources (local defined as within 300 miles). This is the 'Baseline' data. By year three, all five school districts had grown their local procurement to an average of 34%. More detail on these statistics is available in attachment 1.

Objective four was to create California specialty crop Guidebook for School Lunches. The subcontractors, Evans & Brennan LLC, worked to create forty seasonal recipes featuring regional California specialty crops. Those recipes formed the basis of the book "California Specialty Crops: A guide to their use in School Lunch" which also walks the readers through how the scratch cooking classes and staff professional development was created. It is available for digital download on the website: www.HarvestHubYolo.com/Guidebook. These recipes, consisting of more than 50% specialty crops, were also scaled up in serving sizes of 50 to 100 using NutriKids requirements. The design of the Guidebook was facilitated by subcontractor YoloArts and features artwork from their signature "Art & Ag" program. Additionally, the California Dairy Council, which is a member of the grant Advisory Council, ensured that the recipes met the NutriKids requirements and were scaled up to serving sizes of 50-100. The guidebook was dovetailed into objective five - project outreach.

Objective five was dedicated to project outreach. The Project Director and subcontractors attended a series of professional meetings and conferences. Meetings included local and regional groups such as the County Nutrition Action Plan, the Yolo Ag & Food Alliance, the California Farm to School Network, the National Farm to School Network, and the Yolo Farm to School Coalition. Conference attendance included presentation of the following specialty crop topics: Procurement--Getting specialty crops to the School, Art & Ag--Using the Art of the Guidebook to communicate deliciousness, Scratch Cooking--working with the facilities you have to get the food you want, Marketplace Exchange--What happens when you put school food service and farmers in the same room?

Conferences that were attended and presented at include the School Nutrition Association, The National Farm to School Conference, The California Small Farm Conference, the Childhood Obesity Conference, the California Agricultural Commissioners Conference, and the California Farm to School conference. At each of these, project staff shared the Guidebook featuring California specialty crop recipes, and results from the latest trainings.

The overall scope of the project benefitted only specialty crops. Funds were solely used for the teaching, training, procuring, and processing of California specialty crops only. No program elements intersected with non-California specialty crops. The evaluation staff tracked school food service invoices to ensure only specialty crops benefitted.

Contributors and collaborators for this project included: Yolo County Ag Commissioner, Marketing/Training Firm-Brennan from Evans & Brennan LLC, Marketing Firm-YoloArts, Woodland School District, Davis School District, Esparto School District, Winters School District, Washington School District, California Dairy Council, Yolo County Office of Education, Head Start Program, and University of California Sustainable Agriculture Research & Education Program.

Goals and Outcomes Achieved

Outcome one, the project staff created an online directory of farms for schools to a) Easily locate farms interested and willing to work with them and, b) Download the Guidebook with recipes and information on Scratch Cooking, which is available on the website: www.HarvestHubYolo.org. This website features all specialty crops featured in the Guidebook and annotates them by season in the digital Guidebook download. All recipes are also available online in large cafeteria serving sizes of 50-100. All grant participating School Food Service subcontractors used the website at least once; thus, meeting the expected measurable outcome that 100% of school food service in Yolo County will use the site at least once.

Outcome two, the baseline data in the first year of the project showed that all school districts were procuring at an average of 15% of their total produce from local sources (within 300 miles). Focusing on developing the palate and skillset of front line food service staff as a means of encouraging greater awareness of seasonal product with the forty-five cooking classes over the three year project, there was an increase of procurement to an average across school districts of 34%. The target was 35%, so project staff has missed it by one percentage point, but the improvement from 15% to 34% is still tremendous, and translated into $583,275 in sales for local farms over the two year, nine month grant period.

Outcome three was to prepare fifty regional farmers for growing, packing, handling, distributing and delivering specialty crops to school food service. Project staff held three large farmer training events and one small one. Each of the large farmers training events focused on overcoming the obstacles to accomplishing sales with schools including: Food safety, delivery issues, and liability insurance. Interviews at the start of the program with farmers helped to define those issues and shape the trainings. The first two farmer trainings were panels with subject matter experts discussing the issues and questions from the audience on topics like price, facilities, third party food safety certification, and procurement success stories from outside the county. The third training was a "Marketplace Exchange," pairing school food buyers with farmers in a matchmaker speed dating type format to begin to meet and greet, and make sales. Of the three large trainings, there was a total of thirty-eight farmers present. From the large trainings, particularly the third one, 27% of farmers reported making sales with schools on that same day. The intended goal was a 25% increase in sales, and project staff successfully met that goal. The small training took place at the Center for Land Based Learning and engaged fifteen beginning farmers about the details of making specialty crop sales to schools. Topics discussed included how to start a forward contract with a school, how to navigate school paperwork to accomplish sales, food safety certification, and working with a distributor for a school. Total farmers reached through direct trainings was fifty-three; plus additional farmers at statewide conferences.

Outcome four stated that the project will: "Increase the percentage of children who participate in the school lunch program by 15% by the end of the project as measured by school meal participation records." However, in reviewing this objective, it discovered that the meal participation records were more closely related to how well the economy and parents in the community were doing financially. It wasn't an objective that project staff was capable of controlling or influencing as initially anticipated.

Outcome five was to complete a guidebook on the California specialty crops and their Use in School Lunch Guidebook, which was written, designed, and published in February 2015, and distributed to all participating school districts. The Guidebook was also distributed to all California Agriculture Commissioners as a tool to assist their specialty crop growers. The online version of the Guidebook is available at www.HarvestHubYolo.com/Guidebook and was downloaded 358 times at the close of this grant project. The goal was 300 times with 150 stated intentions to use via online download consent. Beyond intention to use, project team has also engaged a Guidebook survey to determine its usefulness. Survey results indicated that 78% of respondents said they learned new ways of incorporating California specialty crops in their menus as a result of reading the recipes and information in the Guidebook. Additionally, 92% of respondents said they were inspired to purchase more California specialty crops for their operation.

One of the Goals for this project was to create a web presence for an online specialty crop farm directory to do institutional sales and to display the Guidebook and have a reported use of the website by 100% of the participating school food service directors. The goal was accomplished, website was set up: www.HarvestHubYolo.com, with online directory of farms ready/able to do institutional sales. One hundred percent of school food service used the website during the course of the project. The website garners about 200 average unique visitors per day who utilize a number of web pages and stay an average of four minutes.

Another goal was to increase average procurement of local produce with data aggregated from all participating school districts from 15% to 35%. Local is defined as being within 300 miles. This goal was accomplished, aggregated average procurement reached 34%. The highest school district procurement reached 94% local of their total produce purchases, with the lowest being 12%.

The goal to prepare fifty regional specialty crop farms for doing business with schools was accomplished. Via three large trainings and one small one, project staff reached a total of fifty-three farmers with concrete information on how to do business with schools including packaging, storing, food safety, delivery and more.

The goal of increasing the percentage of children who participate in the school lunch program by 15% proved difficult to measure because the school lunch participation was influenced by the greater economy and how parents were doing financially. This goal was not met because project staff discovered that it was not influenced by the program activities. The hypothesis was that better tasting lunches would get more children buying school lunch instead of bringing their own lunch; but it turned out that changing the school menu did not increase or decrease school lunch participation. School lunch participation turned out to be related to how the larger economy was doing and not directly influenced by this project. For example, if the economy is doing well, less parents will be likely to use the national reduced school lunch program. The lunch participation statistics stayed relatively the same, fluctuating by 1,000 children over the course of the program.

The goal of distributing information about purchasing California specialty crops including how to menu them via a 75-page web-based Guidebook targeting 300 downloads was accomplished. Project staff also distributed information to all California Agriculture Commissioners. The Guidebook was created and published in February of 2015, with a total of ninety pages, including seasonal menus and forty recipes scaled to cafeteria serving sizes of 50-100. It is available online at www.HarvestHubYolo.com/Guidebook; as of October 2015, the Guidebook reached 358 downloads.

Some of the major successful outcomes for this project included:

Cooking Classes. One of the biggest challenges identified by early stakeholders advising the project was the cooking skills of front line school food service staff, and the lack of available professional development to address this challenge. To undertake this issue, the project staff offered three cooking classes per each year of the project to all five of the school districts for a total of forty-five classes. The classes covered a range of cooking styles and focused on elevating the palate of front line cooking staff with exposure to cuisines from around the world. Each class focused on a different area of the world using California specialty crops and introduced the ingredients and recipes from that ethnic cuisine. Attendees reported that the variety of the foods introduced were interesting. After the classes, attendees also reported that the classes "Opened their minds to combine different ingredients and experiment." They also stated that they liked learning about California products and also about different places around the world. The success of this outcome is rooted in the expectation of these classes can be considered as Professional Development and the understanding that changing minds about cooking is a long, slow process. Project staff anticipate that this outcome will have long-reaching effects on the participants, not easily measured in this grant cycle.

Guidebook. The ninety page Guidebook is a capstone product of the project, offering information about the cooking classes and providing deeper information about seasonal cuisine. The forty recipes feature California specialty crops and information on how school districts, Agriculture department, non-profit, or community farm-to-school group can create their own cooking class series and take scratch cooking in schools to the next level (located on pages 13-14 of the guidebook). The Guidebook, "California Specialty Crops: Guide to their use in School Lunch" is available online. Additionally, all of the recipes are available online in their scaled up version for serving sizes of 50-100, meaning that they can easily be used in a cafeteria setting. Part of the success of this outcome is the joint contributions of many of the grant partners. To accomplish this Guidebook, the Cooking Class subcontractors worked with the YoloArts marketing subcontractor, and also with The Dairy Council of California advisory council member to create the final product. A collaborative project like this worked to incorporate multiple viewpoints, and ultimately offer the strongest possible creation.

Farmer Trainings yielded the most growth over the course of this project. With the three large trainings and one small training for farmers and school food service, project staff learned in-depth about the barriers to making sales. These trainings in particular helped clarify that, although from the outside looking in, it seems as though local farms should be an easy fit for local schools; the process is fraught with layers of bureaucracy and fears of the unknown. Based on experiences with the Farmer Trainings, there are, in fact, three key factors came into play when making sales decisions: 1) Relationship building, 2) Price points, and 3) School cafeteria facilities. It was discovered that if school buyers and farm sellers had a strong, direct relationship with one another, they did better buying directly from the farm. But, if they had weak relationships and solely relied on a distributor instead, school districts were far less likely to purchase from a farm. Local food is generally more expensive than non-local food. To bring the price point down, schools sometimes discovered that the additional costs of a middle-man distributor made the product cost-prohibitive. This lesson was a case-by-case basis and depended entirely on the distributor that schools were working with. In terms of facilities, one key takeaway was the difference in product usage in the cafeteria: Scratch cooking for an entrée versus being used raw in the salad bar. To begin the working relationship with a school district, it was discovered that the easiest point of entry is often the salad bar, primarily because schools don't always have facilities to create and cook entrees from scratch. Whereas dealing with farm fresh product for the salad bar was often an easier leap to make with raw product because it required washing and maybe knife skills, depending on the type of produce. In terms of time, through this project, it was discovered that it takes between three to six months for a school to start procuring directly from a farm and fully establish a buyer/seller relationship. Project team uncovered exactly what layers of paperwork are needed between the farm and the school in order to do business; specifically the need for a W-9 and Proof of Liability Insurance along with possible third party food safety certification. Project staff considered this a tremendous success to have uncovered the obstacles to sales between school districts and farms; and subsequently, overcome them. A strong success of this project was increasing the number of direct farmer/school buyer relationships. These relationships will grow and develop over time, exponentially increasing the impact of this project long term.

Beneficiaries

There are 52 farmer beneficiaries growing commodities such as broccoli, cabbage, carrots, cantaloupe, cauliflower, celery, cilantro, sweet corn, cucumber, endive, grapes, green beans, kale, kiwi, lettuce, nectarines, onions, peaches, peas, pears, peppers, plums, potatoes, spinach, squash, strawberries, tangerines, tomatoes, watermelon. These farmers were targeted for training on how to market specialty crop produce to school districts. Specialty crop farmers who benefitted included: Produce Express, Gold Star Foods, Capay Valley Farm Shop, Happy Valley Fresh Fruit Company, SB Voelz Farming, Appert Farm, J&J Farms, Humble Roots Farm, Reynolds Ranches, Riverdog Farm, Pacific Star Gardens, Heart Fork Farm, Capay Organic, California Endives, Peterson Ranch, Coco Ranch, CLBL Farm Academy, Singing Frog Farm, Loving Nature Farm, JSM Organics, Gibson Canyon Farm, Martell Ranch, Menagerie Hill Ranch, Reveille Ranch, The Cloverleaf Farm, Abbot Organics, Bypass Farms, Casa Rosa Farms, Gauchito Hill Farrms, Godoy & Bigleti Ranches, Good Humus Produce, Guru Ram Dass Orchards, Leap Frog Farm, Martin Family Farms, Orangewood Farm, Rock Bottom Farms, Vreseis Farm, Heavy Dirt Farm, West Sacramento Urban Farm, Impossible Acres, Vierra Farms.

Yolo County School Districts and Head Start: Davis Joint Unified School District, Woodland Joint Unified School District, Esparto School District, Winters Unified School District, Washington (West Sacramento) Unified School District, and Yolo County Head Start.

Number of schoolchildren reached via National School Lunch Program enrollment: 29,903. Number of front line school cooking staff: 35. Number of attendees at conferences: 75. Number of Stakeholder agencies: 23. Number of Advisory Council members: 60. Number of Grant Subcontractors: 8.

Lessons Learned

Project staff learned that cooking classes helped raise skillset and awareness, but not necessarily sales. For this pilot project, it was hypothesized that a greater awareness of how to work (i.e. cooking from scratch in the school cafeteria instead of just heating things up) with raw product from local farms would result in more purchasing of the product. It was discovered that, although having a broader cooking skillset and knowledge of specialty crops is very helpful in a cafeteria setting, it’s not the primary leverage point that makes sales. Whether a school district increases use of local farm fresh product in their program is dependent on that program. The process of ordering and menu creation primarily comes through the School District’s Nutrition Services Director. And that Nutrition Services Director may or may not engage with local farms for a variety of reasons: How comfortable they are ordering direct from a farm instead of a distributor, how much money they have available in their budget, whether or not they have a central kitchen, how quickly they can assign a purchase order in the name of the farm (Purchase Order= internal district paperwork that functions like a credit card), and others. One of those considerations is definitely the skillset of their front line cooking staff. But again, data indicates that it is not the primary leverage point to make sales. It is still an important aspect of the equation of how to work with farm-direct product in schools. It makes no difference if the school district purchases product from farms if the front line cook staff doesn’t know how to work with it. So, although increasing the line staff’s ability to cook from scratch didn’t equate to increased sales of local farm product, it does need to be an important part of the conversation.

Also, project staff learned that building strong relationships is what makes the sales. Experience with the third Farmer Training, the matchmaker/speed dating style event entitled Marketplace Exchange, is where project staff learned that the relationship between a School District Nutrition Services Director and the Farmer is the bedrock of making sales. To facilitate a relationship, it seems to take a series of meetings and follow-ups to make something happen. The general timeframe experienced was three to six months for sales to really get going. Through this pilot project, project staff evolved a system leveraging the 'Meet & Greet' scenario of the Marketplace Exchange, then following that up with taking individual School Nutrition Services Directors on curated Farm Tours to meet farmers one-on-one and further the sales relationship. From there, project staff worked to ensure that the farm's weekly (or bi-weekly or monthly) availability listing made it to the school district along with the required paperwork (W-9 form and proof of liability insurance). After that, following up at the school district level to confirm that a purchase order in the name of the farm was issued; thereby opening the gates for doing business. With this pilot program, it was learned that this type of 'high-touch' relationship driven approach to sales is what is necessary to foster a culture of buying and selling between schools and farms.

Crop Data was extremely helpful. When project staff started working to facilitate sales relationships between schools and farms, it was found that farms needed a little bit more data on the specialty crops that the school district had used the prior school year. This data seems to help farms get prepared for sales with that particular school district in the current year.

Online marketplaces are difficult to facilitate, an online directory is more efficient. One of the early hypothesis was that if an online marketplace was built, buyers and sellers would use it to make sales. An online marketplace was built and project staff held sparsely attended trainings on how to use it. It was discovered over time that the tool wasn't easily used by either farmers or school food buyers. If the tool was used, then it came about as a result of the project coordinator prompting the users to either input their product for sale or prompting the buyer to buy. But it was not spontaneously used by either buyers or sellers to make sales. Again, it was deduced that it was behind the scenes relationship with the project coordinator that made the process work, not the availability of the tool itself. So, in year 2, the tool was changed from making online sales into a more directory format, which is still used today. This directory format turns out to be easier for buyers to search for product information and take to the next level of contacting the farm if they choose. Additionally, in a directory model, farms don't have to constantly update their product listing, which was a drawback of the previous online marketplace set-up. Another important lesson learned was that the online directory needed strong promotion in order to make institutional buyers aware of its presence; doing so is an ongoing initiative.

One of the biggest unexpected outcomes was the information that was learned about the layers of bureaucracy and paperwork on the school district side in order to make sales. For example, a school can't just order on an ad hoc basis from whomever they would like to do business with. For starters, if the sales of a particular item are greater than $84,000, then that item has to go out to a public bidding process, and any other distributor can place their bids on it. However, school districts can weight their bids with preferences like 'organic' or 'local' to help make sure that local foods are given a fair opportunity, instead of opting for the cheapest bid from a distributor who may bring in cheaper non-local foods.

In addition to bid paperwork, project staff learned the importance of the purchase order at the school district level. The purchase order is an internal credit card that the School Nutrition Director sets up in the name of the particular farm and assigns a dollar value. They can then add money to the account as needed, but that internal purchase order is required before the school district can begin ordering from the farm.

On the farm side, with regards to paperwork, farms need to be prepared to sign a W-9 form and offer a copy of their proof of liability insurance in order to jumpstart business with schools. Besides that, school nutrition directors may do the ordering of the product, but they are not the ones responsible for paying farms. Instead, another person in the school district called the Chief Business Officer is responsible for ensuring that the farms get paid. And if something happens to be wrong with the payment, then it is the Chief Business Officer with whom the farm works to correct it.

Unexpected outcomes like paperwork at the school district level help account for some of the slow adoption or stimulation of sales relationships between buyers and sellers. It really represents a huge change in the culture of buying and selling. School buyers not only need to personally meet the farmer they'll be buying with, but the relationship needs to be strong enough for a school nutrition director to want to go through all the layers of paperwork to internally commence ordering from a local farm.

The only goal that should have been re-thought was the increase in school meal participation. Project staff anticipated raising the school meal participation rate by 15% as a result of having scratch cooked meals and better quality food. However, it turns out that school meal participation is much more dependent on the larger economy and how parents are doing financially, not as a reflection of the quality of food produced at the school.

USDA Project No.: 25	**Project Title:** Real Kids, Real Food Farm to School Program	
Grant Recipient: Sierra Harvest	**Grant Agreement No.:** SCB12025	**Date Submitted:** December 2015
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Project Summary

The mission of Sierra Harvest (formerly Live Healthy Nevada County) is to educate, inspire and connect Western Nevada County families to fresh, local, seasonal food. Over the past 3 years, this project supported a replication of a pilot farm to school program throughout the county and built capacity in the following pilot programs: field trips to local farms; using seasonal, local crops for Harvest of the Month tastings and education; cooking classes with seasonal specialty crops through "Tasting Week," as well as hands on experiential learning using school or community gardens and seasonal garden stands to improve fresh food access at school. Farm to school Director and Coordinator serving K-8 students in Nevada County have successfully implemented the expansion of farm to school program from a pilot into an established model for other communities. Sierra Harvest has measured results of increased awareness and consumption of fresh, local, seasonal food.

Over the past decade**,** childhood obesity and food insecurity have been on the rise in Nevada County. Before the Sierra Harvest farm to school program, there had been inadequate nutrition education related to the health importance of specialty crops, and access to healthy foods in schools could be improved. Sixty-eight percent of Americans are now overweight or obese and children are one of the most rapidly growing overweight population. Food insecurity in Nevada County is currently at 30%.

Sierra Harvest expanded its work from a pilot program, to a county-wide Farm to School initiative which began the slow work of reversing these trends by providing access to fresh, affordable fruits and vegetables in schools, introducing nutrition and agriculture curriculum, and by creating robust relationships between students, their families, and the specialty crop growers in this county.

Expansion of Sierra Harvest's farm to school program over the past three years has also directly supported participation in the healthy school meal program, endorsed by all county superintendents, whose goal is to move to preparation and cooking of fresh food for all students in the county. Together, these programs are setting the stage for a lifetime of healthy food choices for the families involved, supporting a thriving local food economy with increased demand for specialty crops, and acting as a replicable model for other rural communities.

Project Approach

Activities and tasks performed include:

1) Acquire produce for school garden carts from farm partners, home gardeners and gleaners.
   Garden carts ran at 14 partner schools providing over 4,000 pounds of produce from local specialty crop growers, and additional produce from home gardeners and gleaners.

2) Secure and coordinate starts and seeds donations for garden carts
The first year, starts were donated by local farms to the garden carts. Because the starts were donated, many were stressed and not in prime condition, and there was not much variety in the plant sales. The solution Sierra Harvest used for the remaining 2 years was to purchase plant starts from specialty crop growers, leading to better quality starts, increased support of specialty crop growers and better diversity of starts. Additionally, Peaceful Valley, a local nursery and garden supply company, donated seeds.

3) Garden carts run weekly providing sampling and nutrition handouts as well as produce sold on a donation basis. Seeds and starts sold March-May.
At all schools, the garden carts ran during the fall season, with produce sold on a donation basis (produce doesn't have a set price, instead customers are provided with a suggested donation). Farm to school liaisons sampled local specialty crops from the carts and gave out recipes and nutrition handouts as needed. All schools sold starts in May and over 2,100 starts were sold.

4) Collate garden cart data from previous season
All cart data is reported within this report.

5) Farm field trips to local partner farms
82 farm field trips happened at 14 participating specialty crop growers. Ten field trips per year of the grant occurred at the Food Love Project.

6) Guest chef cooking demo event at each participating school
"Tasting Week" happened each fall at all schools, with guest chefs demoing local, seasonal produce and fun recipes for specialty crops.

7) Family Fun Night Nutrition Event
Sierra Harvest attended 2 family fun nights and several other school sponsored events such as back to school nights, festivals and celebrations to promote the farm to school program and educate students and parents about specialty crops.

8) In-school nutrition classes
Initially, in school nutrition lessons were offered, but Sierra Harvest decided that putting energy into Tasting Week would be a better use of the chefs and their resources.

9) Harvest of the month produce and educational materials were produced and delivered to all classrooms monthly.
Over 20,000 pounds of local produce was sourced and distributed through the Harvest of the Month program to 270 classrooms. Harvest of the Month tastings happened each month of each school year during the grant period.

10) Harvest of the month lessons and tastings conducted
Lessons and tastings were conducted, with students saying things like "this cabbage tastes like magic!" and "Wyatt likes this cabbage and Wyatt doesn't like ANYTHING."

11) Schedule in school farmer visits

In school farmer visits were challenging to schedule because not all farmers feel comfortable in a classroom setting. 30 of these visits occurred and they were very popular.

12) In-school farmer visits (assembly, slide show, tasting, ag class and/or garden consult)
30 in class visits from farmers occurred where kids planted seeds, learned about farming and tasted fresh veggies straight from the farmer.

13) School Garden support (quarterly consultation or lesson and starts/seeds delivered.)
Schools with gardens received support on a yearly basis and Sierra Harvest was available for support, advice and starts as needed.

14) Income from garden carts goes to back into farm to school programming.
All income earned from the garden carts was kept in designated accounts at each school with the income earmarked for continuing the program. Any money spent from these funds was reported to Sierra Harvest along with the receipt and what the funds were used for.

15) FTC Replication Trainings, tips, tools, and resources for neighboring counties
2 Replication trainings were conducted for 25 people from neighboring counties. Sierra Harvest continues to be a resource for these programs and has received positive feedback on the training. Additionally, a training video was produced and can be viewed here: http://sierraharvest.org/resources-2/farm-to-school-resources/replication-training/

16) FTSL and Farm Docent Trainings
Farm to School Liaisons (FTSLs) attended monthly meetings and trainings the last Monday of the month during the school year. At these meetings, lessons and tasting trainings were conducted.

17) Press releases promoting partner farms
Partner farms have received press through Sierra Harvest's monthly Harvest of the Month/Farm to School spotlight column in the Union, through the Sierra Harvest blog and website and also through custom posters on the garden carts and at participating schools.

18) Conduct intake "pre" surveys with participating school children and "post" surveys after 1 year's time.
Surveys were conducted each year of the program for Pre-surveys for 3rd and 6th grades and Post-surveys for 4th and 7th. Results can be found in the Goals and Outcomes Achieved section of this report.

19) Analyze surveys and logs from previous year, program review, update website
Each year, surveys were analyzed and data reported in progress reports. Final findings can be found in the Goals and Outcomes Achieved section of this report.

20) Hire FTSL's for upcoming school year.
FTSLs were hired for all schools in a timely manner, and many liaisons continued with the program for all the years it has been running.

21) Farm partners to sign agreements for upcoming school year.
Farm partner contracts are on file for all participating specialty crop growers.

22) New schools sign up to participate in FTS program for upcoming school year.
Each year of the program, new schools have been added on in a timely fashion.

23) Develop organizational and program brochure and distribute to families and school personnel.
Brochures were developed and distributed to all participating schools' faculty, students and their families.

24) Do demo lessons in school gardens.
Demo lessons were done at one participating school, and others are interested in pursuing this opportunity in the fall of 2015.

25) Grow starts and produce for plant sales and garden stands.
Over the course of the grant over 840 starts were grown by Sierra Harvest's educational farm, the Food Love Project. This farm also provided approximately 1200 pounds of produce for garden stands during the grant period.

All of the Harvest of the Month featured items were purchased from specialty crop growers, and all of the farmers who provided produce for school garden stands are specialty crop growers. Only specialty crop growers were invited to do demonstrations in the schools and to be part of the farm to school program. Sierra Harvest interviewed and assessed each farmer to be sure they are a specialty crop grower.

Project partners include:

UCCE - has donated in kind services as well as supplemental financial assistance for school gardens and taste tests.

The Nevada County Public Health Department - continues to provide guidance on farm to school programming and utilizes the same monthly Harvest of the Month featured items in their programming countywide.

Nevada County Grown - has been an influential link in connecting farmers to schools allowing specialty crop growers access to an increased market for their products, this organization represents 87 specialty crop growers countywide.

The specialty crop stakeholders that contributed to the implementation of this project are the farm partners: Dinner Bell Farm, Food Love Farm, Riverhill Farm, Sweet Roots Farm, Starbright Acres Family Farm, Woolman Farm, First Rain Farm, Boxcar Farm, Bluebird Farm, Super Tuber Farm, Indian Springs Organic Farm, Foothill Roots Farm, Soil Sisters Farm and Mountain Bounty Farm.

Goals and Outcomes Achieved

1. Develop consumer knowledge of and loyalty to local specialty crop growers in Nevada County's K-8 student population to 30% as measured by the number of surveyed students who can name a local specialty crop grower they buy produce from:

The activities that supported this outcome are as follows: farm field trips, in school farmer visits and farmer promotion onsite at school garden stands. Sierra Harvest measured an 80% increase in the amount of surveyed students who could name a local specialty crop grower over the course of this grant period (from 30% to 54%). Additionally, loyalty is tracked by surveying whether students say their families buy local produce and whether it's bought from farmer's markets, produce stands or CSA programs. From this data, Sierra Harvest has tracked a 59% increase in purchasing local produce from the aforementioned sources (from 29% to 46% of families.)

2. Increase access to affordable specialty crops from 7 to 14 Nevada County schools, and from 30% to 75% of the school year, as measured by the number of schools and number of days that garden stands have fresh local produce for sale by donation on campus:
The activities that supported this goal were the garden carts, which were present at all participating schools in the fall. While the number of schools served by this program increased to 14 by the grant's end, the percentage of the school year that local specialty crops were available was limited to about 10 weeks in the autumn due to growing season. However, with this understanding, Sierra Harvest was able to increase the quantity of produce purchased from local specialty crop growers during this time.

3. Increase consumption of local specialty crops on garden stands from 1,000 pounds/year to 9,000 pounds/year as measured by the number of pounds in and out per day on each garden stand:
The metric was supported by the garden carts and was difficult to measure in practice. A better measure would be how quickly the carts "sell out" of produce. 5,000 pounds of produce was provided by specialty crop growers to school garden carts over the course of this grant period, with many selling out within an hour.

4. Increase the preference for specialty crops from an average of 10% to 50% of students among participating school children as measured by the number of students who state that they like a given specialty crop before and after trying it at tasting event. (Tasting events include Harvest of the Month, Guest Chefs, Garden Stands, and Family Fun nights):
The baseline average was found to actually be about 69%. After three years of successful Harvest of the Month tastings of a diverse selection of local specialty crops, Sierra Harvest has tracked 86% of surveyed students like the produce items they are tasting, a 17% increase! Anecdotally, students are asking for cabbage at home and eating persimmons and kiwis in the school lunch program, which previously had gone to waste.

5. Increase interest in farming specialty crops by 25% in participating student population as measured by the number of surveyed students who say they are interested in being a vegetable farmer on a retrospective pre-test:
The activities which supported this goal are farm field trips and in school farmer visits. According to the retrospective pre-test there was no change in interest by students for becoming a farmer when they grow up. Approximately 60% of the kids, pre and post have no interest at all in being a farmer. This could be for a number of reasons. Farming is hard work, and understanding how much work goes into creating fresh, local food is as important as desiring to do this work yourself. In the future, this metric could be changed to reflect the students understanding of the value of farming beyond the desire to do so. Anecdotally however, the project has changed some students' minds. Recently an elementary school student came to the educational farm and asked the farmer; "Will you still be farming here when I am old enough to be a farmer? Because I want to be a farmer and I would like to farm here. Maybe I could take over when you are done farming!" Sierra Harvest changed the post survey question to "Is farming a good job?" and 54% of surveyed students

said “Yes,” 40% said “Maybe” and .06% said “No.” Sierra Harvest has concluded that 15% more students think that that farming is a good job than when the project started.

6. Support 30% more participating students, teachers, and parents in making more informed shopping decisions and having a greater inclination towards seasonal local specialty crops as measured by the percentage change in surveyed students, garden stand shoppers and family fun night attendees who say they buy local produce after receiving nutrition information:
62% of students surveyed reported that they are likely to buy local, a 21% increase from baseline data.

7. Support of the addition of at least three farms to school programs in rural California and Nevada County as measured by the number of trained county representatives who can rate their confidence level in starting a farm to school program at 7 or higher out of 10 points:
After completing 2 successful farm to school replication trainings, with representatives from 5 counties, Sierra Harvest continues to support the creation and maintenance of other rural FTS programs, including one in Truckee, one in Coloma and one in Cool. An attendee of the training had this to say about it, “Just wanted to thank you for providing a very helpful presentation last week. The thumb drive will serve as an important tool to both swiftly adopt some of your strategies as well as provide funders with a clear picture of a dynamic program. I am looking forward to the produce carts. I see this as a great culture creator for parents and students. All details of the evening were perfect. Thanks for expanding the importance of nutrition education.” After the training, all in attendance reported an increase in confidence and excitement to start a farm to school program in their area. Sierra Harvest remains in contact as a resource to these program attendees.

Rate your confidence level on a scale of 1-10 in starting a Farm to School program in your community?
Pre: 42.86% put confidence as a 10
Post: 100% put confidence as a 10

How likely are you to start or expand a farm to school program in your area? Options: Not likely, Somewhat likely, Likely, Very Likely
Pre: 42.86% said “Very Likely”
Post: 100% said “Very Likely”

8. Increase the number of teachers who use their school garden to deliver standards-based lessons during school hours by 20. As measured by the number of teachers who sign up for trainings and by the number of times they bring their classes out to their school gardens:
Due to scheduling issues with participating schools, the school garden training did not happen in the spring as planned. Baseline was not tracked. There are over 250 classrooms in the schools that staff work with so it would have been too hard to track how often those teachers were going out pre-program. There are currently 20 teachers who are interested in attending the training when it happens (fall 2015 or spring 2016).

9. Grow 840 starts for spring plant sales (at 14 schools) and produce for garden stands at 2 schools at our Food Love educational farm as measured by number of starts and pounds of produce delivered to schools:
The Food Love educational farm grew a variety of specialty crop starts (over 840) for 14 schools including strawberries, kale, chard, lettuce, tomatoes, eggplant, cucumbers and squash. The farm also provided 600 pounds of produce each for 2 schools per year of the grant. The Food Love Farm was a farm partner for 2

schools, but also conducted field trips for other schools when participating specialty crop growers could not do it.

Successful outcomes of the project include:

- 25% more students like the fruits and veggies they try during Harvest of the Month tastings
- 80% more students can name a specialty crop farmer
- 59% more students report that their families shop directly from specialty crop farmers (at CSA's, farmers markets, etc).
- 55% more students know what "local produce" is.
- 28,000 lbs local produce was distributed in schools
- 90% of field trip attendees want to go back.
- 15% more students think that farming is a good job

Beneficiaries

Beneficiaries include:

Twenty-one specialty crop growers who provided services or produce to this program received significant exposure and marketing through participating in the program. Anecdotally, Sierra Harvest knows that after each Harvest of the Month tasting students are dragging their parents to the farmers market or supermarket to buy that specialty crop item and that after guest chef visits, we have students going home in droves to make the recipe they learned at school. It is difficult to say how this translates into future sales, but these farmers and farms now have celebrity status at these schools and high name recognition.

The specialty crop stakeholders that contributed and benefitted from the implementation of this project are the following specialty crop growers: Dinner Bell Farm, Food Love Farm, Riverhill Farm, Sweet Roots Farm, Starbright Acres Family Farm, Woolman Farm, First Rain Farm, Boxcar Farm, Bluebird Farm, Super Tuber Farm, Indian Springs Organic Farm, Foothill Roots Farm, Fresh Starts Farm, Honey Circle Farm, Soil Sisters Farm, Kaki Farm, Mountain Bounty Farm, Pearson Family Farm, Shared Abundance Farm, Riverdog Farm, and Sunset Ridge Farm. Specialty crops grown by these farmers include squash, zucchini, potatoes, garlic, onions, kale, tomatoes, peppers, etc.

The 14 partner schools (and the 4,000 students attending them) benefitted from the completion of this project by learning about specialty crops and the nutritional benefits of specialty crops.

If only the 680 *additional* students who say their families now buy from farmers markets, CSA's etc, shopped for local produce 4 times a year, spending an average of $20 per shopping trip,that would be an increase in sales of $54,400/year for local specialty crop growers.

If the 680 *additional* students who now LIKE the specialty crop they tried at school buy that specialty crop one time for their family, that would generate an addition of $1,360 per month for local specialty crop growers. If those same families bought that specialty crop 3 times (for many families it becomes a regular weekly purchase) that would generate $4,080 per month for 10 months or $40,800 a year in additional revenue for local specialty crop growers.

If each specialty crop grower got one CSA customer each time they were featured in a Sierra Harvest article that would equate to approximately $500 x 12= $6,000 in additional sales for specialty crop growers.

If the 1,000 *additional* students who can now name a local specialty crop grower buys from this grower one time with an average purchase of $20, that would generate an addition of $20,000 for local growers. If these same students buy from the specialty crop grower 3 times, that would be $60,000 in additional sales for local specialty crop growers.

Together these add up to a very conservative potential of $161,200 in additional sales per year for local specialty crop growers.

Lessons Learned

The farm to school liaison model proved to be very successful and could be applied for different projects or goals in the future. Initially, Sierra Harvest restricted this position to be a parent or community member, but as some schools requested teachers take on this position, it became clear that having a teacher in this position was excellent for many reasons. Teachers are ingrained in the culture of the school, can have students take on aspects of the farm to school program in an educational way, and can easily schedule and promote the program with their peers.

Another lesson was around the Harvest of the Month program- the most effective way to run this piece of programming with so many different stakeholders was to make it as easy as possible. Eliminating any need for cutting or cooking then packaging the produce in classroom sized bags or boxes was very effective.

Working with local specialty crop crowers had its own share of challenges: difficulty communicating, and scheduling, getting farmers to feel comfortable with students on their farms and coming into the classroom all took a fair amount of coaching and relied heavily on personal relationships. As the project became more established, farmers became more comfortable with aspects of the program and needed less coaching.

One impact that was impressive was the reduction in food waste due to the Harvest of the Month programming. After students had tasted persimmons and kiwis in the classroom, it was reported that they were eating more of these items in school lunch. Working with the school food service director has been a slow process and the reduction in food waste had her asking how staff can collaborate further with Harvest of the Month in the cafeteria. After a few years of positive feedback, Sierra Harvest was invited to collaborate with Child Nutrition Services.

Sierra Harvest was able to achieve success with outcome measures, but a lesson to share would be to try surveys on actual students and participants before implementing full scale. Also, spending time analyzing those surveys for the data desired so that needless questions are not asked.

Additional Information

None.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 26	Project Title: California Farmers' Market Consortium	
Grant Recipient: Trust for Conservation Innovation	**Grant Agreement No.:** SCB12026	**Date Submitted:** December 2014
Recipient Contact: Laura Deaton	**Telephone:** (415) 421-3774 ext 10	**Email:** laura@trustforconservationinnovation.org

Project Summary

The impetus or motivation for the implementation of this project included combination of factors, including a high incidence of nutrition-related diseases among eligible working poor, and low consumption of fruit and vegetables. The eligible working poor disproportionately suffer from nutrition-related diseases. Price and availability are factors in low consumption. In the recessionary year of 2009, when this project was created, there were high levels of unemployment and even higher numbers of eligible working poor. Farmers who produce fresh fruit and vegetables were also struggling. The bold goal was to achieving new sales for farmers and increase access to fresh fruit and vegetables at an affordable level, and helping to reduce the occurrence of nutrition-related diseases. This was a win/win opportunity: increased income for specialty crop farmers, increased access to fresh fruit and vegetables for people living at poverty levels, and better health and nutrition amongst California's poorest residents.

The California Market Match Consortium (CMMC) was designed to fulfill three goals to increase the promotion and marketing of specialty crops through California certified farmers' markets, farm stands and community-supported agriculture (CSA) farms: 1) to expand the income of small and medium-sized fruit and vegetable growers; 2) to increase access to fresh fruits, nuts and vegetables to a consumer base that uses food assistance programs, specifically reaching the underserved communities that suffer disproportionately from nutrition-related diseases; and 3) to demonstrate the power and efficacy of coordinated statewide action by a team of motivated community-based organizations. The approach has worked. CMMC has aided more than 840 specialty crop farmers and 37,000 federal benefit customers. By linking organizational partners in 16 California counties, it has rewired communities around a farmers' market core, and the consortium is a robust example of how broad-based, nonprofit collaboration can have measurable impact on the entire state and enhance the competitiveness of specialty crops.

In 2009, the Roots of Change (ROC) project received the first of four grants, totaling $1.9 million in Specialty Crop Block Grant Program (SCBGP) money, from the California Department of Food and Agriculture (CDFA). During the 2009-10 pilot year, six partners expanded EBT (Electronic Benefit Transfer) access to 46 farmers' markets in six counties, spurring fundamental changes in buying patterns by federal nutrition benefit program clients. A match program offered EBT cardholders an incentive bonus based on the value of fruits, nuts and vegetables they purchased at eligible farmers' markets. Within the first two years, the CMMC expanded to 17 counties, covering the families most in need. Subsequently, the consortium leveraged philanthropic support to increase the number of farmers' markets with EBT access and Market Match, and increased regional and statewide access to federal nutrition benefit clients. Throughout, the CMMC added new partner organizations, expanding regional reach and increasing partnerships with organizations working to connect vulnerable communities with farmers' markets. By 2012, 32% of all California certified producers were participating in CMMC. They generated total project sales of $879,131 in 2012, a $263,000, or 43%, increase from 2011 ($616,437), and a $555,000, or 171%, increase from the pilot year ($324,350).

During the timeline of the Work Plan, the project was able to: (1) document best practices discovered by the CMMC during the first 3 years; (2) enable more markets to accept nutrition benefits; (3) increase the number of nutrition benefit clients who use the markets, (4) increase outreach and communications promoting specialty crops to volume purchasers such as home preservers, chefs and corner stores by offering them special services for shopping at markets; and (5) prepare the transfer of the CMMC to a new coordinating organization.

Project Approach

Monthly reporting of CalFresh and other federal benefits recipients, including seniors:

- For those farmers' markets that are year-round, monthly data reporting was collected for the target consumers accessing federal benefits, like CalFresh.

Design and facilitate a learning community with partners, including trainings and meetings:

- 10 monthly conference calls were conducted, as well as two, two-day, in-person meetings (held in Oakland in February 2013 and Los Angeles in October 2013) with all partners in attendance, at which there was on-going training to ensure that materials and messaging solely benefited California specialty crops (SC). In-person meetings solely benefited specialty crops in that they were used to discuss matters pertaining to or affecting the Market Match program for the purpose of directly and solely benefits specialty crops. The meetings allowed CMMC partners to discuss program best practices, exchange tools and resources, and contribute to overall programmatic direction, efficacy and sustainability. An internal Market Match Consortium website was created for communications and sharing of meeting information, such as agendas, best practices, and reporting forms: https://sites.google.com/a/ecologycenter.org/market-match-consortium/.

  In addition, the Ecology Center (EC) visited each subcontractor's site to monitor performance, review processes, and to ensure that the Grant directly and solely benefitted California specialty crop producers.

Work with farmers' market managers and specialty crop (SC) farmers to provide assistance in data collecting and technical difficulties with EBT:

- EC worked with each partner on EBT issues and data collection.

Partner with 11+ organizations throughout California to reach out to residents through materials:

- Outreach materials were distributed by all 11 partners, in the form of posters, flyers, billboards, bus advertisements and other print media, promoting specialty crops and Market Match at 134 farmers' markets.

Establish top-up incentive programs at new and existing markets to better address needs in certain communities and boost SC farmer incomes:

- During this grant year, 134 farmers' markets participated in the Market Match program.

Implement consumer surveys at all targeted farmers' markets:

- The CMMC Survey Committee revised the Consumer Survey and over 400 surveys were collected.

Generate local and statewide media support highlighting work of partners and communities:

- In October and November 2013, ROC conducted an extensive social media campaign using Facebook, Twitter and email. ROC communicated 58 times with up to 80,000 ROC followers. The messaging focused on highlighting the compelling nature of specialty crops and California's position as a specialty crops state.

  In addition, ROC developed a report describing results from the first four years of the CMMC project. This report is extensive due to the number of partners and complexity of the activities. Costs were covered with ROC's funding from multiple philanthropies. ROC hired a media team with its funds from philanthropy to generate stories for mainstream media about specialty crop promotion. This goal was successfully achieved.

Evaluate program results and share them and lessons learned with partners and the greater farmers' market industry:

- ROC developed a report describing results from the first four years of the CMMC project. This report is extensive due to the number of partners and complexity of the activities. The costs were covered with ROC's funding from multiple philanthropies. ROC has hired a media team with its funds from philanthropy to generate stories for mainstream media about specialty crop promotion to CalFresh and WIC (Women, Infants, and Children) clients. The 2012 Cluster Evaluation can be found at: http://www.fairfoodnetwork.org/sites/default/files/2013%20Cluster%20Evaluation%20Final%20Report_%20final_10.4.13_Dec2013.pdf. No SCBGP funds were used to develop the 2012 Cluster Evaluation. ROC raised separate funds for this purpose. Also a report detailing the history of the Market Match program, the CMMC, and its successes has been written and will be publicly released.

  CMMC partners conducted outreach and formed strategic partnerships with school districts, hospitals, senior centers, local churches, food banks, food pantries, television and radio stations, newspapers, local businesses, and more than 100 community-based organizations serving local residents. Their expansive multilingual promotion, advertising and outreach campaign reached California's many diverse communities in English, Spanish, Hmong, Punjabi, Vietnamese and Chinese. Along with the partners in the CMMC, the EC will continue to standardize Market Match across the state and move from a highly successful pilot to a ubiquitous statewide program.

CMMC partners attended monthly phone calls and a twice annual, in-person meeting at which there was on-going training to ensure that materials and messaging solely benefit SCs. In addition, the EC visited each subcontractor's site to review processes and to reiterate this program requirement.

Goals and Outcomes Achieved

Leverage matching funds from philanthropic support and distribute top up tokens or veggie prescription vouchers to CalFresh and other federal benefit recipients including seniors, thereby resulting in $700,000 in SC sales for farmer at participating markets:

- $138,512 in additional philanthropic funding was leveraged to achieve $879,131 in SC sales, exceeding project goals. No SCBGP funds were spent for activities associated with fundraising. All personnel and subcontractors have provided additional in-kind contributions to cover all activities related to fundraising.

Partner with 11 organizations to distribute Market Match materials to 1 million Californians:

- 18,606 outreach materials were distributed, such as flyers, brochures and posters. Although ROC partnered with 17 organizations for outreach, the goal of reaching 1,000,000 Californian consumers was not easily measurable and will be discussed in lessons learned.

Expand existing or start new top up programs for a total of 75 farmers' markets:

- Goal exceeded with participation from 134 farmers' markets.

Increase nutrition benefit redemption rates in at least 60 of the veteran markets by providing Market Match incentives:

- This goal was exceeded with increased redemptions rates in all 134 markets.
  - 11 partners distributed Market Match in 134 markets
  - New customers served – 7,488
  - Total CalFresh customers served - 30,433
  - Market Match funds distributed - $171,077
  - CalFresh funds distributed - $711,603
  - Total additional Farmers' Market revenue benefitting SC Producers - $1,037,742

Increase participation in CalFresh by establishing pre-enrollment screenings in 10 farmers' markets:

- 479 clients were pre-screened in 22 markets, exceeding this goal.

Offer 3 seminars to partners to prepare them to apply new market services that will increase volume sales and offer 20 hours of technical phone support to Community Based Organizations (CBO) applying new approaches:

- In February and again in October 2013, two-day Market Match meetings were held (Oakland, then LA) bringing all the partners together to share best practices. In addition, EC held check-in calls with every partner to assess their project. ROC and EC worked with additional community-based organizations (CBOs) and farmers' markets to implement a similar Market Match program in their markets. Goal for technical assistance achieved effectively through two face-to-face meetings and 12 monthly technical assistance calls, as well as through ad-hoc technical assistance upon request. These techniques proved to be more effective and interactive than seminars would have been.

Administer 50 customer surveys that question purchasing patterns at eligible farmers' markets to determine the role of the top up incentive on SC purchases:

- Goal exceeded, with 710 customers completing surveys.
  - 96% of customers surveyed reported that Market Match was slightly important, moderately important, or very important in their decision to purchase specialty crops.
  - 71% of customers surveyed reported that because of Market Match, the amount of fruits and vegetables they buy has increased.
  - 78% reported that as a result of Market Match, they are buying many different kinds of California specialty crops.

- Top up incentives at farmers' markets are an effective tool to increase the purchase and consumption of specialty crops.

140 vendors were surveyed. Key results included:

- 80% of farmers agreed that Market Match helped them sell more fruits and vegetables.
- 69% of farmers reported that Market Match helped bring new customers to their stalls.
- 72% of farmers reported that Market Match helped bring more repeat customers to their stalls.
- Nearly 20% of farmers are increasing their acreage as a result of Market Match.
- Nearly 30% of farmers have developed or offered new or different specialty crop products as a result of Market Match.
- Nearly 13% of farmers have started a green or hoop house to extend their growing season as a result of Market Match.
- Specialty crop farmers and consumers benefitted substantially from the Market Match program.

Identify statewide organization dedicated to the long-term management of the program:

- Goal was accomplished with the EC assuming leadership of the Market Match program. The Ecology Center's Farmers' Market Program is planning to implement a Market Match program in its four certified farmers' markets. Participation in the Market Match program by the EC will improve the EC's understanding on what it takes to establish and administer a Market Match program and will ultimately enhance the competitiveness of specialty crops.

Monitor implementation, evaluate program results and share with CA farmers' markets:

- This goal was achieved. The 2012 Cluster Evaluation has been finished and can be found at: http://www.fairfoodnetwork.org/sites/default/files/2013%20Cluster%20Evaluation%20Final%20Report_%20final_10.4.13_Dec2013.pdf. A report detailing the history of the Market Match program, the CMMC, and its successes has been written. A final draft of this report will be publicly released.

Generate local and statewide media support highlighting the work of the CMMC partners and their communities' access to healthy, fresh and affordable fruits, nuts and vegetables:

- In October and November 2013, ROC conducted an extensive social media campaign using Facebook, Twitter and email. ROC communicated 58 times with up to 80,000 ROC followers. The messaging focused on highlighting the compelling nature of specialty crops and California's position as a specialty crops state.

  In addition, ROC developed a report describing results from the first four years of the CMMC project. This report is extensive due to the number of partners and complexity of the activities. Costs were covered with ROC's funding from multiple philanthropies. ROC hired a media team with its funds from philanthropy to generate stories for mainstream media about specialty crop promotion. This goal was successfully achieved.

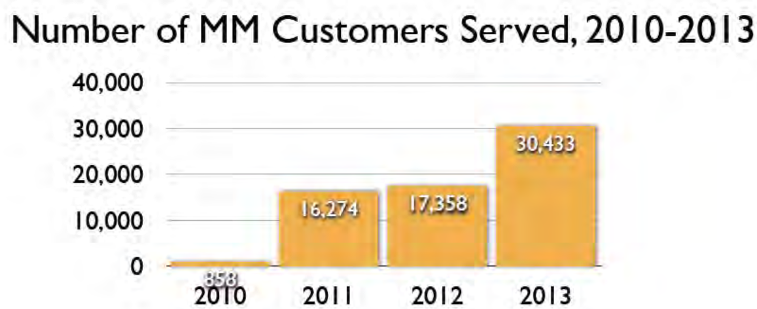
Beneficiaries

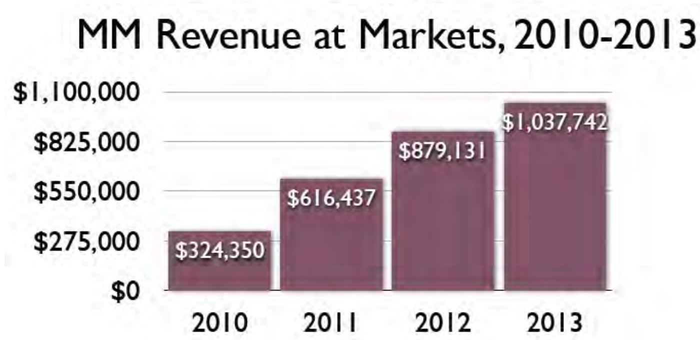
CMMC Partners served a consumer base in 17 California counties at 134 farmers' markets, especially in underserved communities that suffer disproportionately from nutrition-related disease. Agricultural Institute of Marin operates farmers' markets in Marin, Alameda and San Francisco counties; Alchemist Community

Development Corporation partners with farmers' markets in Sacramento and Yolo County; North Coast Growers Association operates farmers' markets in Humboldt County; Puente de la Costa Sur partners with farmers' markets in San Mateo County; Visalia Farmers' Market operates farmers' markets in Tulare County; Agricultural & Land-Based Training Association works in Monterey, San Benito and Santa Cruz Counties; Fresno County Economic Opportunities Council operates farmers' markets in Fresno and Madera Counties; Hunger Action Los Angeles partners with farmers' markets in Los Angeles County; Pacific Coast Farmers' Market Association operates farmers' markets in Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara and Solano counties; Sustainable Economic Enterprises of Los Angeles operates farmers' markets in Los Angeles County; and Phat Beets operates farmers' markets in Alameda County.

Specialty crop producers in the target markets listed above were also direct beneficiaries of the project.

- 11 partners distributed Market Match in 134 markets
- New Customer served – 7,488
- Total CalFresh customers served - 30,433
- Market Match funds distributed - $171,077
- CalFresh funds distributed - $711,603
- Total additional Farmers' Market revenue benefitting SC Producers - $1,037,742





Lessons Learned

Many of the earlier lessons learned by ROC, EC, and CMMC partners had already resulted in significant process improvements, particularly in the areas of survey collection and systematizing reporting and billing processes across all collaborating partners.

EC and ROC supervised six students through a University of California, Berkeley's Service Learning Project in order to interview and transcribe 10 CMMC partners' institutional knowledge and best practices of promoting specialty crops. The interviews will be used to distill lessons learned and qualitative information regarding the differing approaches for promoting specialty crops.

The project's major unexpected hurdle was that the ROC moved to operate under a new umbrella organization. This impacted partners because of associated delays in billing and payment processing. Even so, all services were still delivered by partners without interruption, so recipients of the program were not affected.

On the program goals, ROC realized that it did not have a strong methodology in place to tally its goal of reaching 1,000,000 Californians through outreach. Printed outreach tools numbered 18,606, yet many other forms of online outreach were also used, including partner websites and social media. ROC's Facebook posts alone could have reached 4.64 million readers, but this data cannot verify how many followers actually read the notices. Future projects should put in place an advanced tracking system to better quantify these numbers (web hit monitoring, audience interaction on website, click-throughs, etc).

USDA Project No.: 27	Project Title: Child care/Pre-school Fruit and Vegetable Gardens	
Grant Recipient: Western Growers Foundation	**Grant Agreement No.:** SCB12027	**Date Submitted:** December 2015
Recipient Contact: Sabrina Blair	**Telephone:** 949-885-4789	**Email:** sblair@wga.com

Project Summary

Although half our plates should be fruits and vegetables, the majority of America's children go without eating one serving of produce each day. Thirty percent of U.S. children are obese; half are overweight. This is the first generation of Americans at risk of having a lower life expectancy than their parents. Children participating in edible gardens are more likely to eat produce. "If they grow it; they'll eat it," says a California kindergarten teacher. Approximately half of California's three to five year old children attend child care agencies (child care sites/pre-schools).

Two recent studies of California child care agencies reveal servings of fruit and vegetables are well below recommended levels. A child's food choices, as well as the parent/guardian choices, are influenced by Garden-enhanced Nutrition Education (GENE) taught through experiential school garden lessons. Children who are involved with edible school gardens: planting, tending, and harvesting fruits/vegetables are more likely to eat more fresh produce. This grant provided 100 grants of $1,000 each to preschools/childcare site which had an impact on: (1) nutrition education related to fruit and vegetable food choices for pre-school children; (2) the foods served at their homes; and (3) California's specialty crops served in the USDA Child Care Food Program to pre-school children in California.

This grant builds upon the work from the 2010 Specialty Crop Block Grant Program (SCBGP) Project 16 grant. Western Grower Foundation (WGF) in partnership with California Department of Education (CDE), was able to award 100 pre-schools and child care centers $1,000 to grow and sustain their own fruit and vegetable garden. As mentioned, the project had 313 applications for 100 grants which were awarded in January 2012. Since then, there have been numerous additional inquiries for grants. Staff at CDE and WGF honed a process which is effective and fair for all, and wanted to build upon this success with a second round of grants.

Project Approach

- Awarded 100 preschools/childcare sites with $1,000 each to grow and sustain a fruit and vegetable garden
- Delivered garden and education supplies to each participating site
- Created and administered on-line survey of grant recipients and published best practices on website, http://www.csgn.org/best-practices-pre-k
- Conducted at least 5 site visits
- Received on air coverage of site visits from San Diego KCBS Channel 8 and KUSI Channel 9; the link for this coverage can be found at the end of the report under additional information.

Grant recipient schools were instructed to use grant monies towards specialty crops for the fruit and vegetable garden. Upon completion of spending the monies, the schools submitted copies of receipts for all of their purchases to ensure that grant funds were spent accordingly.

CDE, particularly, the Nutrition Education Consultant, was instrumental in promoting the grant applications and also reviewing the applications that were submitted by applicants.

WGF staff, in addition to administering the grant (accounting, sourcing materials and promotion) coordinated site visits, created and administered an online survey before reviewing and publishing results on website.

Goals and Outcomes Achieved

Western Growers Foundation and project partners, CDE staff reviewed 172 applications. From those applications, 100 preschools/childcare sites were awarded $1,000 grants to create a fruit and vegetable garden which added to 100 previous school gardens created with prior GENE grant. WGF and CDE used a scoring rubric in reviewing all grant applications. The scoring rubric assigned points based on information provided about the school and garden space (i.e. location, size, access to water and sunlight, etc.), the number of subjects and projects that would be taught in the garden, what the money would be spent on, what specialty crops would be planted and general sustainability (i.e. teacher/parent participation, volunteers, etc.). After tallying the scores, the schools with the top scores were chosen to receive the grants.

Approximately a year after the grants were awarded, WGF asked each school to complete an online survey to gather best practices. Of the 100 schools asked to complete the survey, 58 schools responded reporting 3,500 students participated in the garden which exceeds the goal of serving 2,000 children. The best practices were then reviewed and published online at http://www.csgn.org/best-practices-pre-k on June 15, 2015.

The goal of creating 100 fruit and vegetable gardens in preschools or childcare centers was achieved and over 3,500 students participated in the gardens which exceeded the goal of 2,000 participants. The best practices that the project team gathered from online surveys were published later in the grant period but the goal of having 1,000 page views was met with a total of 1,793 views.

At least 3,500 students participated in the school gardens according to the survey data from 58 of the 100 schools. That number far exceeds the project goal and increases the impact of this grant that much further.

Beneficiaries

The California produce industry represents more than $20 billion dollars. As children learn to enjoy fruits and vegetables through participation in school gardens, not only is individual personal health being improved, but supporting one of the state's most important industries is an added beneficiary. Additionally, a child's increased taste for fruit and vegetables often relates to increased consumption of such foods by their parents. Each grant recipient school and their students (approximately 5,000) benefitted from the creation of fruit and vegetable gardens through WGF's grants. From the survey responses, teachers shared the impact the grant and subsequent garden has had on the students.

WGF estimates that approximately 5,000 students benefitted from the grant and likely the same amount of parents were impacted garnering increased consumption of fruits and vegetables.

Teacher Testimonials:
"Seeing the joy in the children's eyes when they find a worm in the dirt or pull seeds out of a flower, watching them taste for the very first time, a sun-ripened tomato and helping to educate the future on nutrition and showing them how easy and fun it is to be healthy."

"The garden has become a source of pride for the children. It has inspired them to try new foods, particularly veggies, and has even encouraged a few parents to start gardens at home."

The center families continue to be surprised when children are seen eating a vegetable such as squash. Simply watching it grow, caring for it and helping to pick it, clean it, cook it and serve it motivates almost every child to try at least one bite. The project team has found that the children will eat almost anything raw. Nearly 60% of Oakland population qualifies as low income and fresh fruits and vegetables are not something that is readily available at home. The project team has noticed significant changes in what the students want to eat, and several parents reported that visits to a weekly farmers market are being made per the child's request.

Lessons Learned

There were some delays in reviewing and publishing the survey results online but the goal was met despite the short timeframe. Specifically, in the Work Plan, activities to conduct surveys on best practices, lessons learned, and nutrition awareness were delayed. The reason for the delays in publishing the results online were due to delays in gathering the results. The survey feedback came from the project activities that took place till the end of the project. In the future WGF will provide ample time to review and publish the survey results so that there can be a deadline which can better incorporate the survey results, and the activities necessary to achieve and complete the survey earlier into the work plan timeline.

Additional Information

Air coverage of site visits from San Diego KCBS Channel 8 and KUSI Channel 9 below:

CBS's coverage:
http://www.cbs8.com/story/23781459/children-at-new-life-head-start-build-a-garden

WGF's coverage:
http://westerngrowersfoundation.org/news/new-life-head-start-gets-ready-fall,
http://wga.com/magazine/2013/12/05/wg-foundation-helps-preschool-%E2%80%9Cgardeners%E2%80%9D-get-ready-fall,
http://wga.com/press-releases/san-diego-head-start-children-%E2%80%9Cgardeners%E2%80%9D-get-ready-fall.

USDA Project No.: 28	**Project Title:** Tasting California Specialty Crops in the Classroom	
Grant Recipient: California Foundation for Agriculture in the Classroom	**Grant Agreement No.:** SCB12028	**Date Submitted:** December 2015
Recipient Contact: Judy Culbertson	**Telephone:** (916) 561-5625	**Email:** Judy@LearnAboutAg.org

Project Summary

Obesity rates are rising and students need more access to fruits and vegetables, and specialty crops can become an important tool for introducing youth to healthier food options. Fruit and vegetable tastings of specialty crops will lead to better educated third through eighth grade students, as these students will have the opportunity to learn about the different varieties and benefits of specialty crops through taste tests and educational resources within the classrooms in hopes that increased specialty crop consumption will occur with these students.

This project is both timely and relative because of recent initiatives that support healthy eating, and the focus on specialty crop nutrition will supplement these initiatives.

Along with other resources developed for this project, teachers will receive the CFAITC student newspaper, *What's Growin' On? Specialty Crops Edition,* in the resource packet. The newspaper was developed through 2010 Specialty Crop Block Grant Program Project 20: *What's Growin' On? 10th Edition- Focus on Specialty Crops*, and is being distributed to more than one million students, teachers, parents and California consumers. This project provides a unique opportunity to broaden current distribution of the newspaper and increase awareness of specialty crops. The specialty crops edition of the *What's Growin' On?* student newspaper is also available in a Spanish version to reach under-served populations.

Project Approach

Specialty crop workshop presentations were provided to university students studying to become credentialed California educators. Against a goal of providing thirty seven presentations, thirty six presentations were scheduled and successfully completed, reaching a total of 896 student teachers. Each student teacher was provided a Specialty Crop Resource Packet that included lesson materials to use in teaching students about specialty crops. The student teachers welcomed the materials received during the workshops and the University Student Teacher Program will continue to be provided at universities in California for years to come. During the workshops, student teachers tasted peaches, comparing fresh to canned, and pears, comparing different varieties.

Mini-grants were awarded to 500 certified California teachers to purchase fruits and vegetables for students to taste in the classroom. Fruits and vegetables tasted were extensive. Teachers reported tasting almonds, blackberries, strawberries, walnuts, pistachios, carrots, avocados, lettuce, melons, peas, peppers, cucumbers, citrus, and more.

Prior to these mini-grants being awarded, project staff developed and delivered a promotional postcard to promote the program to educators and principals in the state, developed specialty crop resource packets, created the mini-grant application, distributed the application, collected completed applications, selected the mini-grant recipients, facilitated attendance of awarded teachers at the 2013 and 2014 CFAITC conferences (47 teachers attended workshops focused on specialty crops), developed a pull-up display for the program, developed a specialty crop seasonality poster for classrooms, and developed journal pages for students. A total of 473 teachers, with nearly 32,000 students in these classrooms, completed the award program and benefitted from the project. Participating teachers were provided with lesson materials to accompany the taste tests. Teachers and students completed pre- and post-evaluations to measure knowledge of specialty crops. Expense vouchers and receipts were collected from mini-grant recipient teachers to substantiate expenditures. The goal was for 500 teachers to complete the program. The teachers that completed the program were very happy with it. Many submitted videos, art work, handwritten notes from students and many other expressions of thanks for the project. One teacher published the taste test experience as a self-published hard bound book.

A web page was developed to feature educational resources that focus on specialty crops including resources developed with this grant, prior specialty crop grants, and other resources available for teachers that solely enhance the competitiveness of California's specialty crops. This project benefitted only specialty crops.

Goals and Outcomes Achieved

The goal of this project was to educate students about specialty crops and have them develop an appreciation for the products and how they can lead to a more nutritious lifestyle, thereby encouraging increased consumption of specialty crops. Pre-and post-surveys were administered to teachers and students in 2014 and 2015 to measure knowledge of specialty crops and consumption levels of specialty crops before and after participation in the program. An online survey tool was used to collect and evaluate the data.

Outcome measures for this project were not long term, though project staff hope that students who participated in the program will consume more specialty crops throughout their lives as a result of the taste tests.

The goal was to survey 50 teachers and 1,200 students regarding the program. Nearly 300 teachers completed the survey and nearly 1,200 students completed the survey.

In 2014, 103 teachers completed a pre-survey asking them to correctly identify specialty crops from a list of five commodities. A total of 154 teachers completed the post-survey. Of the 154 teachers completing the post-survey, 138/154 (89.6%) answered that they agreed or strongly agreed that the resources provided to them were helpful in teaching about specialty crops. On the pre-survey 53/103 (51.5%) of the teachers correctly identified almonds as a specialty crop, while 147/154 (95.5%) correctly identified almonds as a specialty crop on the post-survey. The other commodities listed show similar results, even for the non-specialty crop item listed, rice, which went from 2/103 (1.9%) to 51/154 (33.1%) correctly identifying it as a non-specialty crop.

The students in the 2014 program also completed pre-and post-surveys. A total of 593 students completed the pre-survey and 600 completed the post-survey. The post-surveys showed improved ability to identify specialty crops and non-specialty crops over the pre-survey, especially for rice. On the pre-survey 210/593 (35.4%) of the students incorrectly identified rice as a specialty crop. That number dropped to 152/600 (25.3%) on the post-survey. The students were also asked how many fruits and vegetables they consumed in the previous week. On the pre-survey, 329/593 (55.5%) answered more than five. On the post-survey, 360/586 who answered this question (61.4%) answered more than five.

In 2015 a new group of teachers participated in the program. A total of 180 teachers completed the pre-survey and 86 completed the post-survey. Of the 86 teachers completing the post-survey, 70/85 who answered the question (82.4%) agreed or strongly agreed that the resources provided to them were helpful in teaching about specialty crops. The ability to correctly identify specialty crops from a list of five items improved. For example, on the pre-survey 20/180 (11.1%) correctly identified pumpkins as a specialty crop item while 52/86 (60.5%) correctly identified it as a specialty crop item on the post-survey.

The students in the 2015 program also completed pre- and post-surveys. A total of 556 students completed the pre-survey and 598 completed the post-survey. The post-surveys showed improved ability to identify specialty crops over the pre-survey, for example, almonds. On the pre-survey 277/556 (49.8%) of the students identified almonds as a specialty crop. On the post-survey, 475/556 students who answered the question (85.4%) correctly identified almonds as a specialty crop. The students were also asked how many fruits and vegetables they ate last week. On the pre-survey, 235/556 (42.3%) answered more than five. On the post-survey, 348/598 (58.2%) answered more than five.

More than 80% of the participating teachers who answered the question indicated that the educational resources provided were helpful in teaching about specialty crops (44/53=83% of teachers in the first year and 70/85=82% of teachers in the second year). Nearly 1,200 students participated in the survey. When asked how many fruits and vegetables they consumed in the previous week, the frequency in which students answered “more than five” increased by 5.9 percentage points in both the first and second years of the program.

Beneficiaries

Nearly 500 teachers were provided with educational resources and funds to purchase specialty crops for taste tests in the classroom in which 32,000 students learned about specialty crops, healthy eating habits surrounding specialty crops, and tasted fruits and vegetables in the classroom. The specialty crop industry will benefit from this project because participants now have an increased understanding of California specialty crops and will likely increase consumption of these crops.

Lessons Learned

Teachers were enthusiastic and grateful for the grant and the opportunity to teach students about California specialty crops. Project staff received lots of photos and stories from teachers about their experiences. The amount of mini-grant funding that teachers needed to conduct taste tests during the first year of the program was overestimated, and teachers returned unused funds. During the second year, the amount of the grant award was reduced from $300 to $200 per teacher. Project staff learned that the program needed to be implemented within one school year and not between two, due to teachers moving between school years.

Additional Information

Visit http://learnaboutag.org/caspecialtycrops/ to view resources about specialty crops available for download or hard copy ordering.

One teacher produced a hard bound book that included many pages about the mini-grant and resources used in the classroom and gave a copy to Ag in the Classroom.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 29	**Project Title:** Ecology Center Nutrition Food and Farming Policy Program	
Grant Recipient: Ecology Center	**Grant Agreement No.:** SCB12029	**Date Submitted:** December 2014
Recipient Contact: Martin Bourque, Executive Director	**Telephone:** (510) 548-2220, ext 234	**Email:** martin@ecologycenter.org

Project Summary

The purpose of this project was to ensure the viability of CA Specialty Crop (CSC) growers and health of consumers. The project goals were to: i) create direct sales opportunities for CSC growers with local communities, ii) create farm-to-fork networks and infrastructure, and iii) drive California's $5.7 billion in federal Supplemental Nutrition Assistance Program [SNAP, more commonly known as Electronic Benefit Transfer (EBT)] benefits to CSC growers. California's low-income populations are suffering disproportionately from diet-related diseases; in 2012, one in eight Californians needed SNAP benefits and California was receiving $5.7 billion yearly in SNAP funds, up from $2.5 billion in 2010. Simultaneously, California Specialty Crop farmers struggled with high production costs and losses due to perishability that increases the farther CSCs are shipped. Industrial scale cooling, packing, and distribution houses take the lion's share of profits out of farming communities, making direct sales to local shoppers a critical avenue for many small farmers. The Ecology Center (EC) saw this as an opportunity to drive revenue to CSC growers by directly connecting farmers with new shoppers for the benefit of all. However, making that connection work is complex. Challenges of convenience, familiarity, affordability, infrastructure, policy, and preference must all be addressed. EC's Nutrition Food and Farming Policy (NFFP) programs were designed to address these barriers in order to successfully connect CSC farmers to urban communities with the goal of expanding the market for CSCs and reversing California's epidemic of diet-related diseases. This project focused predominantly on increased CSC consumption and market share by using: i) the Ecology Center Farmers' Markets (ECFM); ii) city-wide Berkeley Food Policy Council (BFPC) planning focused on linking CSC growers to the School District's food, gardening, and nutrition programs ; iii) expanded no-cost physician-prescribed CSCs for 50 low-income families (up from 10) to create a farm-to-fork habit; and iv) technical assistance getting and using wireless EBT devices and Market Scrip for 60 more Farmers' Markets/Associations statewide.

While it began in late 2007, the impacts of the global recession have continued to be felt for many years. Farming communities and low-income communities have been particularly hard hit. The changing economic situation changed people’s shopping habits and the burgeoning awareness of food and movement towards purchasing direct from farmers faltered. Much of the momentum that had led to increased sales by CSC growers in California was lost. For low-income shoppers the situation was equally precarious. In late 2007 just over 2 million Californians were enrolled in CalFresh. By the beginning of 2012 enrollment had soared to almost 4 million participants. The importance and timeliness of increasing revenue to farmers and increasing access to healthy produce for Calfresh shoppers cannot be highlighted enough.

This project was built on previous 2009 SCBGP project 33, 2010 SCBGP project 39, and 2011 SCBGP project 42. Previously funded components of this proposal are:

(1) Assisting a minimum of 20 more Markets/Associations provide EBT access in order to connect more California Specialty Crop (CSC) growers to California's $5.7 billion in SNAP funds. Past SCBGP funding helped EC develop systems, procedures, and materials necessary to assist farmers' markets in becoming EBT capable and to connect CSC growers with EBT funds.

(2) Project 42 supported approximately $3.7 million in direct CSC sales annually. Project 39 successfully reached new customers and facilitated almost $5 million in sales by CSC growers.

(3) Project 39 and Project 42 allowed the Berkeley Food Policy Council (BFPC) to convene a city-wide coalition, complete a strategic plan, and implement coordinated projects.

(4) Project 42 funded a pilot of the Fruit& Veggie Rx (FVRx) program for 10 women. The Ecology Center leveraged that funding to increase the pilot to 35 women and better measure impacts and improve outcomes.

Project Approach

Ecology Center Farmers' Markets (ECFMs) 1/1/2013-12/31/2013:
The Ecology Center Farmers' Markets (ECFM) operated 181 farmers' markets during the course of the grant. Regular meetings were conducted by staff members and leadership to coordinate efforts, review workplan progress, and complete all SCBG reporting requirements. In order to improve access to fresh fruits and vegetables in South Berkeley, ECFM relocated the Tuesday Farmers' Market. As part of this grant ECFM successfully executed targeted outreach to bring new shoppers to Tuesday's market and connect them with CSC growers. ECFM staff also conducted regular customer counts, and completed the annual customer survey. During the reporting period, customer attendance at the Tuesday market increased from a weekly average of approximately 2,000 shoppers to over 2,700, (a 35% increase) demonstrating the success of the outreach efforts.

Berkeley Food Policy Council (BFPC) 1/1/2013-6/30/2014:
The Ecology Center (EC) hosted quarterly meetings of the Berkeley Food Policy Council (BFPC) Steering Committee and regular General Meetings. EC maintained and updated the Stakeholder List Serve. It was originally planned that the BFPC would create a Schools Initiative Working Group to build parent and school district momentum for topics related to classes, activities, and school policies designed to create lifelong consumers of California Specialty Crops. However, momentum within the school district and the parent community independently reached such an active level that the EC was able to skip that step and instead requested that the Berkeley Unified School District (BUSD) create a Superintendent's Advisory Committee (SAC) related to all cooking, gardening, and school nutrition programs. The BFPC had 5 members deeply involved and participating in more than 10 SAC meetings during 2013 and 2 meetings in 2014. Through the SAC, the BFPC helped BUSD with two Board of Education Workshops on the future of their programs. This replaced the need for the 2 additional Community Outreach Workshops. BFPC helped the SAC create a plan for BUSD with 3 options for 2013/2014, and a revised plan for 2014/2015. This replaced the need for an external BUSD Sustainability Study. A BFPC member feedback survey was completed and analyzed.

Fruit and Vegetable Prescription (FVRx) 1/1/2013-3/31/2014:
The Ecology Center successfully renewed its partnership with Lifelong Medical Center to reach at-risk patients. As a result, staff enrolled 50 patients and their families, and 41 families brought their prescriptions to the farmers' market to purchase fresh fruits and vegetables through the grant. The Ecology Center redeemed

FVRx prescriptions at the Ecology Center Farmers' Market for tokens; managed and tracked token redemption; compiled and analyzed Fruit & Veggie Rx data and shopper redemption data; and met with Lifelong Medical to plan, promote and coordinate efforts. The national partnership program was suspended; as a result, additional program elements that encouraged redemption, and engaged in a national analysis of the data were not achieved. FVRx redeemed as part of the grant was $8,495.

Statewide Farmers' Market EBT (SFM-EBT) program 1/1/2013-6/30/2014:
All activities performed in the Statewide Farmers' Market EBT program were toward the outcome goals of increasing the number of California Farmers' Markets that accept CalFresh EBT cards. In addition, the following activities were conducted: a) statewide EBT tracking at markets was increased to include the number of California Specialty Crop (CSC) farmers being served, the number of weeks the market is open, and the exact market location; worked with the California Department of Social Services (CDSS) to provide outreach and technical support to markets for to obtain multiple Point Of Sale (POS) devices under a single Food and Nutrition Services (FNS) number; c) onboarded a new, contracted EBT Program Assistant to assist in technical EBT support and data collection; d) planned and executed the 3rd annual San Diego Farmers' Market Manager EBT training; and e) sent a Fall and year-end edition of the Farmers' Market EBT newsletter, reaching over 500 markets, agencies, and non-profit partners.

To ensure that SCBGP funds solely support the competitiveness of California's Specialty Crops, the Ecology Center invoiced no more than 67% of the Farmers' Market and EBT expenses. The other 33% of expenses were covered by matching funds (well over 100% matching); the matching funds amply cover any unintended contact with ineligible crops or producers.

- SCBGP funding only supported a maximum of 67% of the cost of the EBT staff, consultants, and tokens, in spite of recent data analysis from partner farmers' markets showing that over 80% of SNAP purchases at farmers markets in northern California are for California Specialty Crops (CSCs). This confirms that there is a sizeable cushion between SCBG funding and ensures that matching funds more than covered any activities related to non-CSC purchases.
- From 1/1/2013-12/31/2013, the Ecology Center Farmers' Markets facilitated an estimated total of $9,996,406 in direct sales; the Ecology Center (EC) only reported 67% of this, or $6,697,592, as CSC sales.

The Fruit and Vegetable Rx (FVRx) prescriptions are only redeemable with CSC growers, so EC has invoiced for 100% of the cost of that program, which has solely enhanced the competitiveness of CSC growers.

The Berkeley Food Policy Council now has over 45 organizations and agencies participating and works closely with the Berkeley Unified School District. The Ecology Center's Nutrition Food and Farming Policy programs partner with well over 1,000 California Specialty Crop growers statewide.

Goals and Outcomes Achieved

Ecology Center Farmers' Markets (ECFMs) 1/1/2013-12/31/2013:

Goal— Facilitate $4.3 million in direct farm-to-consumer Farmers' Market CSC sales. a) Expand EC's 4th ECFM to 44 weeks per year; b) increase CSC growers' sales by attracting new shoppers in vicinity of relocated Tuesday Market. Measured via monthly EBT sales reports, and annual farmer and consumer surveys:

The ECFMs were open for 181 Markets total. The Tuesday Market in South Berkeley (51 markets), the Thursday Market in North Berkeley (50 markets), the Saturday Market in downtown Berkeley (51 markets) and the Wednesday Farmers' Market in Albany (29). During this period, the Markets served 52 CSC farmers and over 408,851 local shoppers. The Ecology Center's farmers' market shopper surveys have conservatively estimated average customer spending of $24.45. When multiplied by 408,851 local shoppers, this gives the total sales of $9,996,406 for the calendar year. When multiplied by 67% (to ensure only CSC sales are being reported), CSC sales for this grant are estimated at $6,697,592 exceeding the grant goal by almost over $2 million. This number is larger than previously reported due to higher customer numbers and more accurate customer counts and shopping behavior data. To date all reporting on spending at market has happened at a market level. With more accurate data on the total number of shoppers and their average purchase amount, staff were able to more accurately account for total market sales.

Food Policy Council (BFPC) 1/1/2013-6/30/2014:
Goal-- Use the BFPC's 55 nonprofits, schools, and government agencies to link the Berkeley Unified School District's (BUSD) food, gardening, and nutrition programs. a) Complete 3 community outreach workshops on the current programs, issues, and ways to get involved. b) Produce a BFPC study of long term financial sustainability options for the BUSD programs. c) Convene BUSD stakeholders, staff, and leaders to present the study and create a linked, district-wide food and nutrition plan. Measured by attendance, completion of study, and progress toward adoption of new plan:
The Berkeley Food Policy Council (BFPC) successfully achieved the expected measurable outcome of linking the BFPC to the Berkeley Unified School District (BUSD) food, nutrition, and gardening program. The Ecology Center hosted quarterly meetings of the BFPC and of the BFPC Steering Committee meetings through this grant. These meetings had significant emphasis on BUSD's food, gardening, and nutrition programs. The BFPC also requested and succeeded in getting the BUSD to create a Superintendent's Advisory Committee (SAC). Project staff were able to include 5 BFPC members on the SAC participating in more than 10 meetings. The SAC essentially created smaller, ongoing, and highly productive community meetings, and led to two Board of Education workshops. The SAC used volunteer and BUSD staff time to study short and long-term funding solutions for BUSD and produced 3 options for the BUSD to consider for the 2013/2014 year. In this period, the BFPC members on the SAC also advocated that the BUSD administrators revise and expand the scope of its search for a replacement for the program supervisor resulting in a national level talent search and the hiring of a highly qualified candidate from Washington, DC. The BFPC also advised the BUSD on program and funding alternatives for the 2014/2015 year. On March 7, 2014, the full BFPC voted to endorse a final proposal to the School Board. The School Board voted on March 12, 2014 to adopt a $480,000 program funded through their general fund as a result of the SAC/BFPC recommendation and community support. The Berkeley Healthy Child Coalition has also emerged out of the BFPC as a new coalition to support the long-term sustainable sources of income for this and other related programs.

Fruit and Vegetable Prescription (FVRx) 1/1/2013-3/31/2014:
Goal- Increase CSC consumption for 50 low-income families (approx. 200 people) by connecting them to 47 CSC growers via $22,400 of CSC prescriptions. Measured by prescription redemption rate and participants' pre and post programmatic food behavior surveys:
As was previously reported, staff had originally anticipated participating in Wholesome Wave's national FVRx "proof of concept" phase. As part of this partnership, Wholesome Wave was to provide the national

database for tracking redemption rates, food behavior data, BMI and other health indicators. Wholesome Wave lost their funding and did not execute their national partnership program in California. As such, no national data tracking or analysis was possible and the start of the 2013 program delivery was delayed to provide the Ecology Center and Lifelong Medical Center time to create an alternative plan and tracking system. Ultimately, staff were able to run an effective program. Lifelong enrolled all 50 participants and their families in the program and ran it for the full 16 weeks. Total FVRx redeemed on this project was $8,495, which went to 47 CSC farmers and 41 families (average of 4 family members per household). This came out as an average of $189 of additional revenue per farm and $207 worth of additional CSCs purchased by the families.

Statewide Farmers' Market EBT (SFM-EBT) Program 1/1/2013-6/30/2014:
Goal- Utilize EC's groundbreaking EBT system to get 60 more Markets/Associations EBT capable and provide CSC growers with $300,000 of new revenue, as measured by the number of authorizations from FNS for CFM wireless Point of Service devices and by California sales/usage reports:
Through this grant the Statewide Farmers' Market EBT program helped Markets/Associations to become EBT capable with how-to materials, onsite training, technical assistance, Spanish/English shopper outreach materials, and marketing/promotional assistance. In total, the Ecology Center served approximately 125 farmers' markets with these efforts, benefitting over 1,280 CSC Farmers. Since 1/1/2013, the SFM-EBT program activities directly resulted in adding SNAP Electronic Benefits Transfer card (EBT) access to a total of 62 new Market locations, which provide access to new income for 817 CSC Farmers.

To calculate how this translates as revenue for specialty crop growers, Ecology Center uses the FNS, SNAP redemption reports for California farmers' markets. The most recent, complete numbers released by FNS are for January 1, 2012-November 30, 2012, and show the average annual EBT transactions per authorized market association to be 727 and the average redemption per market to be $15,972. If the 62 markets brought online for EBT sales with this project each made the average of $15,972 in new EBT sales, this would mean that there were 45,074 (62 markets x 727 average # of redemptions) new EBT shoppers/transactions that resulted in $990,264 (62 markets x $15,972 average amount of redemptions) of new EBT redemptions. Applying the same 67%, this shows that $663,477 ($990,264 x 67%) of new EBT transactions went directly to California specialty crop farmers as a direct result of this grant.

The success of this project can be measured using the above information. However, the benefits of this project will continue indefinitely. 62 markets now equipped to accept EBT will continue to do so and will provide additional revenue to their specialty crop farmers for as long as the EBT delivery system remains in place; the new shoppers at the Ecology Center's Tuesday Farmers' Market will continue to shop and provide income to the specialty crop farmers there; the long-term solvency and impacts of the Berkeley Unified School District's nutrition, gardening, and cooking programs will ripple out for generations as a result of the Berkeley Food Policy Council's engagement in the process; and the families who participated in FVRx may feel the benefits of this grant for the rest of their lives as a the result of better nutritional habits, education, and good health.

The Ecology Center successfully achieved the majority of the goals established for this grant

- The Ecology Center's Farmers' Markets exceeded the California specialty crop sales goal of $4.3 million by over $2 million. This was achieved through increased customer attendance and successfully attracting customers to the Tuesday Farmers' Market.

- The Statewide Farmers' Market EBT program assisted 62 new markets in establishing EBT access and creating $663,477 in new revenue for CSC growers. These numbers are well beyond the 20 markets and $300,000 in new revenue described in the original grant application and even surpassed the updated goal of 60 new markets.
- The Berkeley Food Policy Council achieved its goals of linking the BFPC to the Berkeley Unified School District (BUSD) food, nutrition, and gardening program by getting the BUSD to create a Superintendent's Advisory Committee and placing 5 BFPC members on that committee.

The two areas where outcomes did not fully reach the intended Goal were:
- The Ecology Center Farmers' Market (ECFM) in Albany operated 29 rather than 44 markets. While specialty crop farmer participation remains enthusiastic at this Market and there is a growing, loyal customer base, the Ecology Center and the growers chose to close the market in October rather than operating the market through the end of the calendar year. In the final weeks of the market, customer attendance declined significantly and it was deemed best by the growers to end the Albany Market's season a bit earlier than planned. The ECFM program still achieved the overall goal of facilitating $4.3 million in California specialty crop sales.
- The national partner for the Ecology Center's Fruit and Vegetable Prescription program (FVRx) suspended their FVRx work in California. In addition, the Ecology Center's clinical partner was completing a major capital campaign and expansion of their clinic. For these reasons, it was necessary to postpone the start of the FVRx activities from the originally planned start date. The Ecology Center and its clinical partner met to determine the best ways to move forward without involvement of the national partner and were able to make significant program delivery improvements. FVRx activities re-launched in September 2013. The FVRx program successfully recruited 50 participants. The lack of the national partner resulted in the FVRx participants attending market less often than originally expected, so $8,495 was expended for FVRx rather than the expected $22,400.

Average customer attendance at the Tuesday market was 2,000 shoppers. After implementing a promotions plan through this project, customer attendance rose to an average of 2,700 shoppers per week.

Specialty crop sales in 2012 at the Ecology Center's Farmers' Markets were estimated at $4.42 million per year. During the period of this project, the EC was able raise that to figure to $6.7 million.

At the start of the project the number of farmers' markets in California eligible to accept Calfresh was just over 300. That number now exceeds 400.

- The Ecology Center Farmers' Markets operated 181 farmers' markets and generated $6,697,592 for 52 California Specialty Crop (CSC) growers during the course of the grant.
- The Statewide Farmers' Market EBT Program worked with approximately 125 farmers' markets adding EBT access at 62 new market locations, which generated an estimated $663,477 in new income for 817 CSC growers.
- Through the Fruit and Vegetable Prescription Program (FVRx) the Ecology Center enrolled 50 participants and another 150 family members in the program and ran it for 16 weeks. Total FVRx redeemed on this project was $8,495, which went to 47 CSC farmers.
- The Berkeley Food Policy Council (BFPC) was instrumental in saving the Berkeley Unified School District (BUSD) Cooking and Gardening Program by working directly with BUSD administrators through

the Superintendant's Advisory Council (SAC) to develop alternatives to eliminating the program. As a result of this work, the School Board allocated nearly $500,000 of general fund support for the program and incorporated it more deeply into the academic curriculum. The district-wide cooking and gardening programs have been proven to increase the consumption of fresh fruits and vegetables by the University of California Center for Weight and Health.

Beneficiaries

The primary group that benefited from the SCBG funded accomplishments was California Specialty Crop growers selling through farmer's markets. Other groups that benefited from this grant were low-income shoppers (who benefitted from the FVRx program and an increased number of farmers markets accepting EBT), and the residents of Berkeley – with special focus on school-aged children who are developing an early connection to and preference for specialty crops.

Through the Statewide Farmers' Market EBT Program 817 CSC growers benefitted from an estimated $663,477 in new income due to the 62 markets that began accepting EBT. This amounts to $812 of new income per CSC grower. Ecology Center Farmers' Markets benefitted 52 CSC growers during the course of the grant by generating $6,697,592 in sales (up from $4.42 in 2012) or $128,800 in sales per grower. The one-time investment from this grant will yield ongoing benefits to these growers as new customers (EBT and non) will continue to shop into the future. The Berkeley Food Policy Council has implemented an infrastructure and coalition to directly benefit all 115,403 residents of Berkeley, and the grant has especially impacted the 9,410 students in grades K-12 in Berkeley public schools.

Lessons Learned

Through the implementation of the promotions plan for our Tuesday Farmers' market, the Ecology Center learned a great deal about which strategies are more and less effective at bringing customers to the market. For example, EC learned that direct mailings and door hangers in the immediate vicinity of the market are more effective at driving customers to market than newspaper ads.

EC also learned that the interest level among market operators in accepting EBT is quite high. As awareness of EBT at farmers' market grows, EBT customers are more likely to ask whether EBT is accepted when shopping at a new market and the market operators are more likely to reach out to the Ecology Center's Statewide Farmers' Market EBT project for assistance. Providing technical assistance to these markets has proven to be extremely helpful in getting them to move from the point of casual interest to actual implementation.

Working closely with senior administrators to devise alternative solutions resulted in integrating cooking and gardening more directly into the academic curriculum.

Without the national partnership, the former level of clinical involvement for Fruit and Veggie Rx (FVRx) was not possible under this project. The Ecology Center and its clinical partner built a strong alternative, but had fewer resources to assist with patient outreach, retention, and encouragement. As a result, the FVRx recipients attended the farmers' market less often. The Ecology Center's take-away from this experience is that an FVRx program can be very successful, but only if there is significant investment in clinical care.

While this is not a new lesson, it was certainly an important reminder. Farmers and customers have many local alternatives during the winter months, and for many farmers, selling at a farmers' market in the winter is quite challenging. The Ecology Center, Albany residents, and the farmers' who were participating in the Albany market all wanted/requested a year-round market. However, once the cold and rain set in, that commitment to a new market waned on all parts. The Ecology Center was reminded that operating a market seasonally rather than year round is sometimes simply more beneficial for farmers.

Additional Information

- Results of the 2013 Ecology Center Farmers' Market Vendor survey
- Results of the 2013 Ecology Center Farmers' Market Customer survey
- Results of a 2014 member survey from the Berkeley Food Policy Council

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 30	**Project Title:** Best Buds	
Grant Recipient: Healthy Eating Lifestyle Principles, Inc.	**Grant Agreement No.:** SCB12030	**Date Submitted:** December 2015
Recipient Contact: Suzanne DuVerrier	**Telephone:** (831) 241-5012	**Email:** Suzanne@helpchooseyourlife.org

Project Summary

Healthy Eating Lifestyle Principles (HELP) is a non-profit whose mission is to promote healthy eating, physical activity, and the increased consumption of fresh fruits and vegetables. With this mission in mind, HELP implemented the Best Buds (BB) program. BB was a year round multi-faceted nutrition education program promoting healthy eating while combating the obesity epidemic by empowering participants with the knowledge necessary to make healthy food choices and increase consumption of California fresh fruits and vegetables.

The BB program targeted primarily low-income, migrant, and Latino families in Monterey County, a region ravaged by the obesity epidemic. BB was created to expand the existing afterschool and parent nutrition education classes and projects thereby reaching more people throughout the county and in particular, the project's target area, the Salinas Valley. Building on seven years of successful nutrition education projects, BB's goal is to empower participants, from school-aged children to adults, to view good nutrition as the first step in achieving a healthy lifestyle and the first line of defense against obesity and preventable diseases.

BB brings valuable nutrition education that is lacking in elementary schools and provides a venue for adults to receive practical and life-changing information they would otherwise not receive. The prevalence of fast food outlets, the lack of nutrition education in schools, and the food insecurity issues that plague the low-income and migrant target population, create a perfect storm of risk factors.

HELP recognized the lack of knowledge and ability to make healthy food choices of the target population and the inherent health issues that these bring. The BB program was directly developed to address these issues and incorporated California specialty crops as a tool to improve the knowledge of participants necessary to make healthier food choices while directly increasing the sales and consumption of California specialty crops.

According to the Center for Disease Control and Prevention (CDC), the consumption of fruits and vegetables are "important for optimal child growth, weight management, and chronic disease prevention", and 40% of adults (18+ years) in California reportedly eat less than two servings of fruits and vegetables per day. Furthermore, despite being the "salad bowl" of the nation, 63.6% of Monterey County adults are either overweight or obese and 11.9% of children in Monterey County are overweight for their age. Monterey County also has the highest rate of adults in food insecure households in California at 49%.

Schools offer an ideal setting for young students to learn about good health and nutrition. Lessons learned at an early age can help establish healthy eating habits that last a lifetime. BB also targeted parents of these children, educating them about healthy eating and new ways to prepare and consume specialty crops. In this way, BB reached the entire family by reinforcing the message with the parents and caregivers who are the decision makers of the type of food that the children will consume. By promoting the consumption of

California specialty crops, the BB program was able to maximize its impact on the lives of the target population.

An additional benefit and long term impact of the BB program was HELP's work in the Head Start classrooms. There, Head Start teachers received direct and indirect training on how to deliver sound nutrition education curriculum to young pre-school aged children. The knowledge gained by teachers will further the reach of the BB program by enhancing the teachers' work in classrooms in the future.

This project does not build upon a previously funded SCBGP project.

Project Approach

The BB program was carried out in accordance with the originally approved project proposal. HELP diligently carried out all of the proposed activities and tasks during the grant period. Detailed information on the activities completed as approved are as follows:

- Project staff worked hard to coordinate with partners in order to ensure success of the program. Project staff worked with school district staff to schedule the nutrition education classes that were held at school sites each year. Project staff also coordinated with staff from the Boys & Girls Club to schedule family Market Days, nutrition education classes, and chef demonstrations. HELP's partnership with the Head Start program proved successful as project staff delivered and exceeded the number of proposed classes. Coordination of logistics also proved successful as the Food Bank of Monterey County was able to contribute the in-kind donation of bags of specialty crops to be distributed to families.
- During the grant period, project staff delivered a total of 510 one-hour classes at Monterey Park Elementary and Loma Vista Elementary and served an average of 360 unduplicated students. These garden nutrition education classes were delivered to elementary school children from kindergarten through sixth grade. HELP completed providing after school services for the second semester of the 2013 school year, all of the 2013-2014 school year, and all of the 2014-2015 school year.
- Project staff conducted 20 Family Nights, 25 nutrition education classes, 17 Market Days and 32 chef demonstrations/cooking classes at the Salinas and Seaside Boys & Girls Club sites. The number of individuals served by project staff at these sites was 4,855. During Family Nights and Market Days, a total of 107,146 pounds of fresh fruits and vegetables were distributed to families in attendance at no cost to them, through partnership with the Food Bank of Monterey County. Project staff were able to expand the project reach at the Boys & Girls Club by offering a summer nutrition education program.
- Early childhood nutrition education classes were held at different Head Start sites in the Salinas Valley area. An average of 2,005 children were served in 186 three hour classes during the grant period. The Head Start program also consisted of meetings for the parents on a monthly basis. A total of 20 parent meetings were held during the grant period, and an average of 478 parents attended these meetings. In working with Head Start sites, project staff were able to conduct two parent focus groups that consisted of several nutrition education classes. Project staff believe that this intensive lesson plan was extremely well received by parents and proved more meaningful and helpful for them due to the amount of knowledge gained and information received during these classes. Parents learned from the cooking lessons, chef demonstrations, and the ability to take bags of specialty crops home to replicate the recipes learned in the classroom. This style of focus group oriented lessons is one that HELP highly recommends as it proved more effective in changing behavior and significantly increasing knowledge of the parent participants.

- The children at the garden sites maintained the gardens during the year as part of their learning experience and curriculum. During the summer months and school vacations, project staff coordinated with H.O.P.E Services to maintain the school gardens. Over the course of the grant, project staff were able to make significant improvements to each garden and increase the visual aids and hands-on opportunities that kids at these sites had available to them.
- During each reporting period, the project's Evaluator, Program Manager, and HELP's Executive Director worked together to collect the pre- and post-surveys that were distributed to participants during each program. This data was collected, entered and analyzed.

This project solely enhanced the competitiveness of specialty crops. Project activities were centered on increasing knowledge and consumption of California specialty crops. All classes and program activities only included instruction on how to harvest, prepare and cook specialty crops. Project staff tracked all program activities by logging each activity, date, and topic, as well as attendance of each class in order to ensure that funds were used to solely enhance the competitiveness of specialty crops. All records and invoices are maintained as backup of project activities.

HELP was extremely fortunate to have reliable and professional project partners to work with for this program. Having reliable partners makes a significant difference in the ability to accomplish program goals and objectives. This program would not have been possible, nor as successful, without the generous contributions from the project's partners; the Boys & Girls club of Monterey County, Head Start of Monterey County, Food Bank of Monterey County, H.O.P.E Services, and the Salinas City Elementary School District.

Three of the listed partners were instrumental in providing adequate classroom space for program implementation as well as access to the project's target population by directly serving clients/students. These partners are the Boys & Girls Club of Monterey County, which allowed project staff to serve at the Salinas and Seaside sites where nutritional education classes for teens were held and a new garden club was developed at the Seaside site during Year 2 of the grant. Market Days and Family Night events were also held at the Boys and Girls Club sites. Head Start of Monterey County provided project staff with 37 sites in Monterey and Santa Cruz County, where the program was able to reach preschool aged children, parents, and teachers. The Salinas City Elementary School District provided project staff with access to two elementary schools, Loma Vista Elementary and Monterey Park Elementary, to host two after school garden nutrition education programs. Each school provided the outdoor space for the gardens that were outfitted with planter boxes and housed all the gardening tools and equipment so that the children could experience planting and harvesting specialty crops at their school.

H.O.P.E Services was also a key partner that helped to maintain the school gardens during the summer months and when kids and staff were not on campus. The Food Bank of Monterey County contributed 107,146 pounds of specialty crops during the grant, which were distributed to families in accordance with the originally approved project proposal.

Goals and Outcomes Achieved

Project staff hoped to achieve the goal of promoting healthy eating while combatting obesity by working on two distinct objectives: 1. Increase knowledge necessary to make healthy food choices and 2. Increase consumption of California specialty crops. To accomplish these objectives, BB initially outlined two activities to be carried out throughout the grant cycle:

1. **Conduct Nutrition/Garden Education Classes:** These classes took place at various sites with different age groups and populations served. Specifically, the following were the classes that were held:
   a) Garden Club at Loma Vista Elementary and Monterey Park Elementary- For three years, project staff used an innovative instructional model of teaching children about good nutrition through garden-based activities. This way of teaching kids about fruits and vegetables was very successful because they were involved in every stage of crop growth from seed to table. The kids felt more compelled to taste vegetables that they have worked on growing than if the food was just presented to them. The garden was an active tool through which students learned about new fruits and vegetables and their availability during each season of the year. Students participated in nutrition education classes after school for nine months of the school year.
   b) Head Start Early Childhood Nutrition Education- Early childhood nutrition education classes were held at different Head Start sites during the Head Start program year. Through these program activities, the BB program reached varied target groups in terms of age. BB reached young children enrolled in Head Start programs, as well as the kids' teachers and parents. During these classes, participants had the opportunity to gain knowledge about fruits and vegetables, learn new creative ways to prepare them, tasted the fruits and vegetables, and, when possible, took bags of specialty crops home to share with their families.
   c) Boys & Girls Club- The primary focus of the Boys & Girls Club program was to reach participants through Family Nights. Through this program, project staff disseminated nutrition education and shared knowledge of how to prepare specialty crops that were given to these low income families. HELP had the opportunity to leverage additional resources that allowed the creation of a garden club at the Seaside site. During the summer of 2014, project staff were able to expand on their success with the Garden Club at the school sites, to the Boys & Girls club. As a result of this effort, project staff were able to establish and set in place three gardens that, long-term, will continue to serve children in Monterey County beyond the life of this grant.

2. **Family Market Days and Food Distribution at Parent Classes-** This activity primarily took place at the Boys & Girls Club, who hosted the Market Days as well as Family Nights. Project staff participated in the Boys & Girls Club Family Nights during the grant period and coordinated food distribution, in conjunction with the Food Bank of Monterey County, during Market Days. These activities provided low-income families in attendance with access to California specialty crops and information on how to create tastier meals for the family using recipes as well as chef demonstrations.

Although BB outcome measures were finite and by program design were measured after program activities were delivered, project staff hope that participants will continue to practice healthy eating habits and continue to increase their consumption of California specialty crops throughout their lives. Project staff believe that BB program will have a long-term effect on participants' lives.

The BB program goal was established to empower participants with information and resources to embrace good nutrition as the first step in achieving healthy, happy lifestyles and a first line of defense against obesity and preventable diseases, and to increase their consumption of California fresh fruits and vegetables. The activities discussed above directly supported project staff's ability to achieve this established goal during the program. BB's accomplishments include delivery of nutrition education classes that reached a diverse group of participants and effectively taught them new information about fresh fruits and vegetables, including where these crops are harvested, where they can be purchased, and how to prepare them to be consumed. To achieve this goal, there were a number of outputs that the program produced which are directly related to the project's measurable outcomes. A total of 741 nutrition education classes were held during the grant reporting period for all BB target groups directly contributing to the ability of the participants to gain knowledge about healthy nutrition. Over 107,000 pounds of California specialty crops were distributed within the grant period, through Family Nights, Market Days, and parent meetings directly impacting the access and consumption of California specialty crops by participants and their families.

BB served participants that were enrolled in school programs during the grant period. Each year, new cohorts of students participated in BB activities. During the activities, in most cases, pre-survey data was collected to establish the level of knowledge about nutrition fundamentals and current consumption of California specialty crops.

Knowledge Gained:

- 91% of students enrolled in the BB Garden Nutrition Education Program demonstrated increased their ability to correctly recognize fruits & vegetables that were presented to them at Garden Club classes.
- During a timed exercise, students were asked to write down as many California specialty crops that they could think of, pre- to post-surveys results show that students were able to increase their ability to name more California specialty crops by 40%.
- 20% of Head Start teachers stated that they learned how to effectively set up learning centers in their classrooms to facilitate nutrition education lessons.
- 40% of parents stated pre-program that they would eat more fruits & vegetables daily if they knew how to cook them or took cooking classes. 86% of parents stated, post-survey, that they learned new ways of preparing and cooking fruits & vegetables as a result of taking these classes.
- 86% of parents stated post survey that they know more about what types of fruits and vegetables are available in California.

Increased Consumption of CA Specialty crops:

- Post-program, 73% of students reported that attending these classes and garden work inspired them to eat more fruits and vegetables.
- 94% of parents and 64% of students reported that they have increased their intake of fruits and vegetables as a result of what they learned in these classes.
- 69% of the children participating in the garden club reported having changed their eating habits.
- 70% of students report having purchased new fruits and vegetables that were shared with them during the garden classes and 78% reported sharing the concepts that they learned in the garden at home.
- 95% of Head Start teachers reported post-program that preschool aged children were willing to eat more fruits and vegetables.

Part of the project's success was documented through feedback obtained from program participants after the program completion. The following are the results:

- BB program reached 7,895 individuals across all target age groups.
- 94% of participants felt that the content of the classes was useful to them.
- 92% of participants reported that the BB activities they participated in were interesting to them.
- 89% of participants reported that the presentations were clear and easy to understand.
- 92% of participants felt that the classes were well organized.

- Overall, 84% of BB participants across all target groups report that they are eating more fruits and vegetables as a result of this program.
- The BB program took a unique, hands-on approach in teaching children about fun and tasty ways of preparing and eating vegetables. Getting the children to be willing to taste fruits and vegetables that were new to them can be very challenging. Despite this challenge, BB experienced a 21% increase in the number of children in the Garden Club who were willing to, and actually taste-tested new California specialty crops offered to them resulting in a 10% increase of children reporting they liked what they tasted.
- BB was successfully able to distribute 107,146 pounds of California specialty crops.
- BB was successful in inspiring the creation of more garden clubs, establishing two new gardens at the Boys & Girls Club in Seaside and Salinas.

Beneficiaries

BB was designed to serve preschool and school-aged children, their parents, and their teachers. The target population was primarily low-income and predominately Latinos, living in Monterey County. BB served preschool-aged children enrolled in Head Start, their parents, and Head Start teachers, as well as elementary-aged children at two elementary schools and participants in the Boys & Girls Club. Through BB, HELP has furthered the advancement of California specialty crops through participation in BB nutrition education classes. Furthermore, data collected suggests that 86% of program participants learned about what type of fruits and vegetables are available in California. Post-program survey data also shows that 79% of students and parents state they are changing their eating habits as it relates to an increased consumption of fruits and vegetables.

Throughout the course of the grant, BB served a total of 2,005 preschool-aged children enrolled in Head Start programs, 478 parents of Head Start children, and 237 Head Start teachers. At two school sites, through the afterschool nutrition education classes, BB program served 360 unduplicated students in grades K-6. Additionally, BB served 331 school-aged kids participating in the Boys & Girls Club and over 4,524 individuals through activities held at the Boys & Girls Club.

Lessons Learned

Project staff scheduled most of the parent lessons to be combined with chef demonstrations. During these classes parents received information on the nutritional value of the specialty crops used, observed creative and tasty ways of preparing fruits and vegetables that may not have been familiar, and received a recipe card as well as a bag of produce to take home at the end of the class. This approach has proven very effective in giving parents exposure and all the knowledge and tools to replicate what they learned during the classes thus increasing the likelihood of continuing to prepare and consume fruits and vegetables. Based on the observation of project staff, this was a very efficient way of teaching parents and breaking barriers that they may have when they are not familiar with the cost, taste, or availability of unfamiliar produce. Project staff also recognized that if program design allows it, having multiple contacts with adult participants, such as the Parent Focus Groups, allows for the most and best program impact.

Another lesson learned by project staff was the challenges associated with evaluating the effect of the parent classes through surveys. Parents were mostly monolingual Spanish speakers and often illiterate. This proved challenging due to the extra time commitment that staff had to dedicate to help parents with filling out surveys. Staff had to explain questions and answers for parents and had to make sure enough bilingual surveys were available. This challenge became apparent in Year 1 of BB and project staff were able to integrate more measures to reduce this challenge in subsequent years to obtain more and more accurate information from parents. Even with these additional measures in place, project staff still struggled to motivate parents to fill out surveys completely.

There were no unexpected outcomes or results from this project.

One of the most valuable assets to have had in place for this program was the coordination and commitment of project partners. This was crucial to program success and timely delivery of all program activities.

Additional Information

Attachments to this report include:

- ✓ Program Photos: (photographs depicting different program activities and populations served).

FINAL PERFORMANCE REPORT

USDA Project No.: 31	**Project Title:** Backyard Garden Program	
Grant Recipient: City Slicker Farms	**Grant Agreement No.:** SCB12031	**Date Submitted:** December 2015
Recipient Contact: Ariel Dekovic	**Telephone:** 510-763-4241	**Email:** ariel@cityslickerfarms.org

Project Summary

West Oakland is a predominantly low-income community of color classified as a “food desert” and has one of the highest per capita poverty rates in the Bay Area, with 32% of the 25,000 residents living below the poverty level. This makes it difficult for residents to afford healthy food. Twenty-four percent of residents rely on welfare and Medi-Cal (compared to 9% in Alameda County). Surveys show that 86% of the service recipients are low to extremely low-income, based on HUD income limits for Alameda County. Forty percent of the families this project worked with lack money to buy food at some point in their monthly routine, from occasionally to once a week.

The scarcity of healthy food options and the prevalence of highly processed foods contribute to high rates of chronic illnesses in West Oakland. Mortality rates from diabetes and heart disease are 1.5 times the county rate. Yet the cost of living in Oakland is approximately 67% higher than the U.S. average, and West Oakland’s increasing gentrification and proximity to wealthier neighborhoods exerts further pressure on its most vulnerable residents. When there are no nearby full-service grocery stores, eating a healthy diet is difficult. Although West Oakland now has a small food co-op, it is not enough to meet the food needs of the community. To access healthy food, many residents (42% of West Oakland residents do not own a car) have to make a 60-90 minute bus ride. There are a handful of fast-food chains and over 40 liquor stores in West Oakland, approximately one liquor store for every two blocks that sell alcohol, tobacco and junk food—but few outlets for fresh food.

City Slicker Farms (CSF) works with low-income families, neighborhood youth, childcare centers and senior facilities to empower residents facing critically important challenge around food access, poor health outcomes, environmental neglect, and displacement from economically shifting neighborhoods. This model of inner-city food production improves environmental integrity and reduces costs associated with food acquisition, having the tributary effect of alleviating some financial burden for low-income residents. This model also builds long-term capacity by developing leadership of local residents within the movement for food success, and by providing agricultural education to youth and adults, cultivating the tools to produce food among residents themselves. Over time these programs have transformed the landscape of West Oakland, impacting land use, environmental stewardship, and neighborhood-wide resources to improve food access.

The Backyard Garden program expands access to healthy, safe California specialty crops at childcare centers and in neighborhoods. By building gardens in homes and childcare centers, CSF brings fresh, healthy specialty crops within reach for low-income adults and children in West Oakland and across Alameda County. Families and children gain access to produce that may have not otherwise be accessible to consume, given the lack of availability of these products in most under-resourced neighborhoods.

The education and mentoring that CSF provides through the Backyard Garden program builds gardening skills, nutritional awareness, and empowers low-income families to gain access to specialty crops, ultimately leading to an increase in overall consumption of these crops. For the childcare centers served by the program, the project team provides curriculum to educate children about nutrition and healthy eating habits.

This project did not build upon a previously funded Specialty Crop Block Grant Program project.

Project Approach

Activities during the entire grant period included:

- Conducted outreach targeted towards extremely low-income residents of West Oakland, including tabling at neighborhood-based outdoor festivals such as Friday Night Live and Life is Living; tabling at organization-specific events, such as a senior center Earth Day event; and physical mailings to potential participants.
- Reviewed applications for the Backyard Garden Program
- Conducted an initial site visit to each home or childcare center, which included discussing shared goals and design for the garden, measuring the garden space, and in some cases testing for lead and heavy metals. In April 2015, under the guidance of the Alameda Healthy Homes Department, and Markus Niebanck, an expert is hazardous material remediation, the project team changed the approach to lead to be a precautionary approach. Rather than testing the soil, which is incomplete and can cause accuracy problems, the team now works with the gardeners to ensure best practices for lead (and other toxin- safe) gardening. After April 2015, every new West Oakland based garden received a barrier on the bottom of the planter boxes to prevent soil contamination. In addition, the team brought in all new soil to fill the boxes (no soil from the site is used). Additionally, where possible, the team mulched the entire yard in order to prevent direct contact with contaminated soil, which can be dangerous when inhaled or directly ingested.
- Built 115 new backyard gardens (including 87 individual households and 28 childcare sites).
- Provided technical support and mentorship for ongoing Backyard Garden Program participants. Each participant received the support of a garden mentor for two years, and longer for those with ongoing challenges such as mobility/wheelchair access, and for community group gardens. The Backyard Garden Program formalized the practice of pairing community group gardens and those gardeners who had additional challenges, such as mental health challenges, or mobility challenges, with a staff member mentor. Gardeners who needed less support were paired with an experienced volunteer mentor. The project team found that this arrangement best leveraged staff time, while providing for a fulfilling volunteer experience for the volunteer mentors.
- Grew seedlings and provide supplies and materials to participants (e.g. seeds, seedlings, soil, compost, etc.). The project team was able to grow over 36,000 seedlings in the community greenhouse annually (note: the greenhouse was already in existence prior to this grant).
- Conducted annual survey and quarterly visits to collect data to measure program performance and changes that participants experience as a result of backyard gardening.
- The project team collected data on the amount (by weight) of fruits and vegetables grown. As a result of these evaluation methods, the project team was able to calculate that the gardeners grew over 29,000

pounds and 32,900 lbs. of specialty crops annually (in 2013 and 2014 respectively). The project team estimated that in the first half of 2015, over 15,000 lbs. of specialty crops were grown and harvested.
- The project team reported on surveys and quarterly mentor visits.

The Backyard Garden Program specifically benefits and enhances specialty crops, and was monitored by the Project Director and accounting staff for compliance.

- The Backyard Garden Program partnered with First 5 Alameda County to bring specialty crop gardens to qualifying childcare sites. The shared goal is to expose children and their families to healthy foods, outdoor activities, and increase their consumption of fresh fruits and vegetables.
- The project team worked with East Bay Asian Local Development Corporation to create food gardens at community centers with the goal of engaging people who are vulnerable to food insecurity, who are beyond the current reach of the project, as well as to look at community development and greening opportunities in the area of West Oakland where CSF focuses its work.
- The American Community Gardening Association (ACGA): CSF staff spoke at their conference about backyard gardening, and the team also hosted a conference bus tour of specialty crop gardens in West Oakland.
- Alameda County Master Gardeners (ACMG): CSF is endorsed by ACMG, an organization dedicated to helping people learn about gardening. CSF worked with the ACMG to promote the growing of specialty crops and troubleshooting pest management. In 2015, the project team hosted a workshop about soil for backyard gardeners, partnering with ACMG and People's Grocery, a local partner organization, to deliver the workshop.
- CSF is also a founding member the Oakland Food Policy Council, a member of the HOPE Collaborative, an active member of the Alameda County campaign "New War on Poverty" and a member of the Building Blocks Collaborative (convened by the Alameda County Department of Health). By participating in these groups, the organization was able to use its on-the-ground experience to inform policy and practices that support the sustainable growth, distribution, and consumption of specialty crops across the city.
- California Children Service Medical Therapy Unit: CSF built a garden on this organization's site for children with disabilities. CSF collected disability information from participants to inform the design of the gardens, accommodated wheelchairs and other mobility issues through the garden bed design.

Goals and Outcomes Achieved

Summary of Work Plan Activities

- The Program Assistant, Garden Program Manager, and other staff members conducted targeted outreach for the program at over ten community events. CSF presented at events and organizations including: Life is Living, the Scion Exchange (a community fruit tree exchange), Black Cowboys Festival, Civicorps Health Fair, Transitional Aged Youth Health Fair, Freedom Farmers Market, Holy Name University Social Justice Forum, and the People's Party hosted by People's Grocery. Outreach took place at the annual Harvest Festival, a free community celebration at one of the market farms, (co-hosted with People's Grocery). Additionally, CSF promoted the Backyard Garden program using direct mail to local West Oakland residents in the form of a printed newsletter, and utilized social media such as Facebook. All of this outreach resulted in a steady supply of applicants for the program. From this CSF concluded that continuation of the outreach activities should take place and will partner with more West Oakland organizations for outreach.

- The Garden Program Manager, Operations Manager, and the Childcare Garden Coordinator provided intake and reviewed applications for the Backyard Garden program. All applications were reviewed for fit with the program (e.g., income qualifications and landlord permission) and then all were contacted to go over next steps (e.g., if qualified, or not, and scheduling a site visit). If an applicant did not qualify for the program (e.g., had a high income), than CSF shared tools and resources for the unqualified applicants to start a garden by themselves. Because of CSF outreach, enough applicants were accepted into the program to meet the target goals.
- The Garden Program Manager and the Childcare Garden Coordinator provided initial site visits for qualifying sites (included education about lead/heavy metals in soil, measuring space, discussing shared goals for the garden, etc.). From the visits, CSF team concluded where to put the garden, and what should be grown.
- The Garden Program Manager and the Childcare Garden Coordinator built 115 new backyard gardens (including 87 individual households and 28 childcare sites). During the builds, staff partnered the sites with a staff or volunteer mentor who provided ongoing support and recommendations for the households and childcare sites.
- The Garden Program Manager, Backyard Garden Mentor, and the Childcare Garden Coordinator provided technical support and mentorship for 356 ongoing Backyard Garden program participants.
- The Operations Manager grew 50,058 seedlings for the project and the Garden Program Manager, Backyard Garden Mentor, and the Childcare Garden Coordinator provided the seedlings, along with seeds, compost, and mulch to participants during the mentor visits.
- The Program Assistant, Garden Program Manager, Backyard Garden Mentor, and the Childcare Garden Coordinator conducted 47 annual surveys (contacted 199 households) and 165 quarterly visits to collect data to measure program performance and changes that participants experience as a result of backyard gardening.
- Garden Program Manager, Backyard Garden Mentor, and the Childcare Garden Coordinator collected data on the amount (by weight) of fruits and vegetables grown and found that 264 households and childcare sites grew 29,800 pounds of produce in 2013 and 26,916 pounds of produce in 2014.
- The Interim Executive Director and Program Assistant completed data collection and analysis for the annual report and program review. This information was then given to staff to review, who made recommendations for changes in the program.

This project provided a community with knowledge about home and school gardens, which will allow the community to provide itself with fresh fruits and vegetables long after this project ends.

Goals versus actual accomplishments:

Measurable Outcome Goals	Results
Through the Backyard Garden project, food self-sufficiency is improved for over 1,400 West Oakland and Alameda County residents who lack access to healthy fruits and vegetables by building 109 new backyard gardens (82 at households and 27 at childcare centers).	5,225 residents gained access to specialty crops through this project. 115 new backyard gardens (including 87 individual households and 28 childcare sites), fulfilling this grant outcome goal.
Before joining the program, only 36% of participants cite that produce was consumed more than once a day - the target is to increase this number to 50%.	2014 survey revealed that 51% of participants ate produce more than once a day, fulfilling this grant outcome goal.
Help at least 80% of participants save money each year by growing self-made produce, measured by annual surveys.	2014 survey revealed that 100% of participants saved money by gardening, fulfilling this grant outcome goal.
Each year, the project will support at least 1,400 participants to grow at least 22,000 pounds of California specialty crops.	1,836 people were served during the first full year of this project. 2,758 people were served during the second year of the program. To date the Backyard Garden program has grown a total of 71,685 pounds of food over 31 months, averaging 27,749 pounds per year, fulfilling this grant outcome goal.
Improve the gardening skills of at least 80% of participants	2014 survey revealed that 77% of participants self-report improved gardening skills

Baseline data that has been gathered to date to show the progress toward achieving set targets:

Outcomes	Baseline Data	4/2013	10/2013	4/2014	10/2014	End of the Grant Period
Participants served: 1,400 West Oakland and Alameda County residents who lack access to healthy fruits and vegetables	0	169 residents	1880 residents	315 residents	2,578 residents	5,225 residents 100%+ fulfilled
109 new backyard gardens (82 at	0	18 gardens built (13 households	31 garden built (21 households	26 gardens built (19	40 gardens built	115 new backyard gardens (87

households and 27 at childcare centers)		and 5 childcare centers)	and 10 childcare centers)	households and 7 childcare centers)	(34 households and 6 childcare centers)	individual households and 28 childcare sites) 100%+ fulfilled
Increase participants who consume produce more than once a day by 14%	36%	49%	n/a	34%	51%	51% of participants currently eat produce more than once a day 100%+ fulfilled
At least 80% should report participants save money by growing specialty crops, measured by annual surveys.	N/A	97% of participants save money by growing specialty crops	n/a	87% of participants save money by growing specialty crops	100% of participants save money by growing specialty crops	100% of participants save money by growing specialty crops 100%+ fulfilled
Each year, the project will support at least 1,400 participants to grow at least 22,000 pounds of California specialty crops.	0	1,694 supported to grow 24,000 pounds	1,880 supported to grow 15,043 pounds	1,756 supported to grow 29,754 pounds		5,225 residents supported 71,685 pounds of specialty crops grown over 31 months, averaging 27,749 pounds per year 100%+ fulfilled
Improve the gardening skills of at least 80% of participants	n/a	60% of participants self-report improved gardening skills	n/a	57% of participants self-report improved gardening skills	77% of participants self-report improved gardening skills	77% of participants self-report improved gardening skills 96% fulfilled

Major successful outcomes of the project:

- Goal Outcome Achieved – Behavior Change to Eat Healthier Foods: Before joining the program, only 36% of participants stated that produce was consumed more than once a day - the target is to increase this number to 50%. The 2014 survey revealed that 51% of participants currently eat produce more than once a day, fulfilling this grant outcome goal.
- Goal Outcome Achieved – Help Low-Income Community Members Save Money on Specialty Crops: Help at least 80% of participants save money each year by growing self-made produce, measured by annual surveys. The 2014 survey revealed that 100% of participants save money by gardening, fulfilling this grant outcome goal.

Beneficiaries

The demographics of the Oakland community are primarily low-income families, childcare providers and senior living facilities in underserved communities of West Oakland. Forty-one percent of garden service recipients are under 25 years of age, 67% of whom are children. Fifty-two percent of participants are adults between the ages of 25 and 65. Seven percent of participants are over the age of 65. African Americans make up 63% of participants; 21% are Euro-American; 6% are multi-racial; 5% are Latino; and 1% are Native American.

5,225 residents gained access to specialty crops through this program. 115 new backyard gardens (including 87 individual households and 28 childcare sites), were direct beneficiaries of this project. The Backyard Garden Program has grown a total of 71,685 pounds of food over 31 months, averaging 27,749 pounds per year, directly benefitting 4,594 Oakland families.

Lessons Learned

CSF developed an evaluation process to gain insights into how the project team might better deliver the Backyard Garden Program.

Information was gathered from the following sources for each topic:

Backyard Garden Program Recommendations

- Analysis of annual survey of backyard gardeners and mentors
- 2 Backyard Gardener Focus Groups
- 2 Mentor Focus Groups
- Compilation of ongoing feedback throughout the year
- Interviews with 2 similar organizations (GardenWorks Project and Mission ASAP)
- CSF staff interviews

Lead Approach Recommendations

- Consultation with Alameda County Healthy Homes Department; Steve Calanog, Federal On-Scene Coordinator at US EPA; Markus Niebanck, EnviroFinance Group; and Nathan McClintock, Assistant Professor of Urban Studies & Planning at Portland State University
- Participation in Get the Lead Out Coalition

- Staff Certification – Alameda County Healthy Homes Department EPA Lead Certified Renovator

The program recommendations can be viewed here:
http://www.cityslickerfarms.org/sites/default/files/byg_recommendations_6_24_2015_scbg_0.pdf

The project team experienced a drop in technical assistance hours for participants. The project team investigated this and found three reasons and provided solutions for each of those:

1. Some of the participants elected not to have mentor visits because of confidence in gardening skills were good and obtaining the supplies necessary were available directly from the CSF greenhouse. CSF underwent a deep program evaluation process, and explored the idea that some gardeners may need less mentorship because of skill level. One of the recommendations for changes was to allow gardens to self-identify the participant's skill level so that the team could pair up with an appropriate mentor and prepare the mentor for the level of mentorship the gardener would need. CSF's intention was to create a positive mentorship experience for everyone.
2. Some of the mentors did not return quarterly mentor visit sheets in a timely manner. The program team used these sheets to get reporting on mentor hours. The Backyard Garden Program needed to use additional staff time to contact all the mentors regularly to mail or drop off the forms. The Program Coordinator changed the process to mail forms each quarter, and this increased the return of the sheets.
3. Some of the participants struggled with paying for phone bills, and are therefore were difficult to get a hold of which also makes scheduling mentor visits difficult. Because of this, some of the participants have requested that mentors just drop by to see if the participant is home and wants a spontaneous mentor visit. Other suggestions were dropping by the CSF office to schedule appointments as well.

The one area of outcomes that the project team was unable to fulfill was around the area of improved gardening skills. The project team worked with a volunteer evaluation specialist to analyze the methods of evaluation in this area, and the evaluator recommended that asking gardeners to self-report this data would result in a lower evaluation of this outcome, as gardeners are likely to be humble in answering the question. The evaluator recommended that program ask mentors to evaluate the skills of the gardener over the 2 years of mentorships; asking the third party in addition to the self-reporting would create a layer of increased objectivity to the data.

Additional Information

Website/Blog Entries that continue beyond the grant project term:

The following links are media and blog entries on CSF website which include some of this project activities as well as news on participants that goes beyond the project term:

- Passing On The Gift Of Healthy Food: Backyard Gardeners Train To Become Health Promoters With Cooking Matters: http://www.cityslickerfarms.org/blog/2015/07/backyard-gardeners-become-health-promoters
- 5 drought-friendly ways to conserve water in a garden: http://www.cityslickerfarms.org/blog/2015/07/5-drought-friendly-ways-conserve-water-your-garden
- Garden Reconnects Tamales La Oaxaqueña Owners To Their Roots: http://www.cityslickerfarms.org/blog/2015/07/tamales-restaurant-garden

- Meet Edith Finch, An All-Star Backyard Gardener: http://www.cityslickerfarms.org/blog/2015/06/meet-edith-finch-all-star-backyard-gardener
- The Value Of Senior Gardens: More Than Just Healthy Food: http://www.cityslickerfarms.org/blog/2015/06/value-senior-gardens-more-just-healthy-food
- Unity Council-De Colores Garden Featured In Green Childcare Video: http://www.cityslickerfarms.org/blog/2015/02/unity-council-de-colores-garden-featured-green-childcare-video
- Backyard Gardeners Build Pruning Skills: http://www.cityslickerfarms.org/blog/2015/01/backyard-gardeners-build-pruning-skills
- The Helen Turner Children's Center Garden Project: A Picture Book: http://www.cityslickerfarms.org/blog/2014/12/helen-turner-childrens-center-garden-project-picture-book
- Description of the Backyard Garden Program on the CSF website: http://www.cityslickerfarms.org/backyard-garden-program

Video

- Video of a time-lapse of a complete backyard garden build: https://vimeo.com/109835810

USDA Project No.: 32	Project Title: Napa Ag in the Classroom Harvest of the Month Program	
Grant Recipient: Napa County Agriculture in the Classroom	**Grant Agreement No.:** SCB12032	**Date Submitted:** December 2015
Recipient Contact: Sandra Elles	**Telephone:** (707) 224-5403	**Email:** selles@napafarmbureau.org

Project Summary

The Harvest of the Month (HOTM) project was designed to address needs within Napa Valley Unified School District (NVUSD) regarding student obesity, nutritional education and agricultural literacy. With only 2% of the nation's population engaged in farming, most students are unaware of the importance of agriculture and how and where their food is produced.

The project also targeted a need for local growers to have access to the institutional buying power of NVUSD and open up new market opportunities for California specialty crop producers.

The "Live Healthy Napa County" (LHNC) Community Assessment reported a clear and dramatic increase in the diagnosis of chronic conditions of obesity and diabetes in children throughout the county and that the diagnosis was happening at a younger age. Over 40% of the fifth, seventh and ninth graders in Napa County are overweight, reflecting a 6.1% increase between 2005 and 2010; this was the largest increase observed among the nine Bay Area counties (see documentation in appendices). Research from the Centers for Disease Control and Prevention shows a connection between healthy dietary habits and positive academic achievement.

Concurrent with the LHNC efforts, the Napa community created a dynamic Local Food Council to focus on enhancing a sustainable local food system, and promoting local food production and consumption. Working in collaboration with the Napa Local Food Council, NVUSD, Sodexo Food Service (NVUSD's food service vendor) and Napa County Farm Bureau (NCFB), HOTM created a perfect platform to utilize a Farm to School program to address student nutritional knowledge relating to specialty crops, health needs, agricultural literacy, and grower options to sell into NVUSD's food service.

This project did not build upon any previously funded SCBGP projects.

Project Approach

The following activities were completed in order to achieve the goals and objectives for the program:

Project Start-up:

- Key personnel and the NVUSD school board were notified (Oct 2012)
- A press release was distributed to announce the grant and emails were provided to principals (Oct 2012)
- The Local Food Advisory Council (LFAC) met to review the project plan (Oct 2012)
- A school-based stakeholders group was established (Oct 2012)
- A subcontract was issued with Spacious Economy Media (Oct 2013)

- The food distributor was established and a monthly calendar was developed with the distributor (Nov-Dec 2012)

Objective One: Voice of the Farmer Project
- A list of potential farmers in the area and crops was created (Oct-Nov 2012)
- Ag in the Classroom (AITC) contacted growers and began formulating the growing calendar (Nov 2012)
- Farmer interviews were videotaped and copies to "Teacher Tube" for video streaming were provided, Spanish translations of the videos were produced (Nov 2013-Jun 2014)
- Five additional FOTM videos and Spanish translations were produced (May 2015)
- Teachers were given links to the Farmer TeacherTube and FOTM profile each month (Feb 2013-May 2015)
- Data was collected and analyzed for quality improvements and reports, and these reports were given to LFAC (Feb 2013-Jun 2015)

Objective Two: Bring Produce to Classroom for Student Tasting
- The program was reviewed with NVUSD principals (Jan 2013, Sept 2014)
- Emails were sent to elementary school teachers with instructions for HOTM tastings and lesson plans (Jan 2013, and monthly thereafter)
- Bowls, knives, and other materials were brought to schools for distribution to classrooms (Jan 2013, Aug 2013, Aug 2014)
- The nutrition instructor trained parent volunteers from all 19 schools (Jan 2013, Aug 2013, Jan 2014, Aug 2014, and Jan 2015)
- A produce of the month schedule was developed with LFAC, growers, and Sodexo (Nov 2012-Jan 2013, Aug 2013 and Aug 2014)
- Food was picked up/distributed to schools monthly for tastings (Feb 2013-May 2015)
- Data was collected and analyzed for quality improvements and reports, and these reports were given to LFAC (Feb 2013-Jun 2015)
- HOTM produce tastings, nutrition lessons and ag literacy program were expanded to After School program serving 400 students at 3 school sites in Napa Unified School District (Oct 2014-Jun 2015)
- Coordinated and delivered nutrition, cooking and ag literacy lessons to classrooms featuring the monthly HOTM local produce (Oct 2014-Jun 2015)

Objective Three: Local Produce to Cafeterias
- A meeting with Sodexo was set up to establish the plan for purchase of local specialty crops (Oct 2012)
- A food distributor and annual produce calendar was set up (Dec 2012, Aug 2013, Aug 2014)
- Monthly communication was held to review progress (Nov 2012-May 2015)
- Data was collected and analyzed for quality improvements and reports, and these reports were given to LFAC and Ag Commissioner (Feb 2013-Jun 2015)

Objective Four: Harvest of the Month
- Reviewed program guidelines at HOTM website (Oct 2012-May 2015)
- Met with Principal appointed stakeholders group to establish best practices for working with teachers (Jan 2013, Aug 2013, Aug 2014)
- Farm Bureau book keeper recorded specialty grant expenses (Oct 2012-Jun 2015)
- Delivered tasting bowls, teacher newsletters, and FOTM profiles (Feb 2013-May 2015)

- Printed HOTM teacher newsletters to distribute to teachers (Feb 2013-May 2015)
- HOTM parent newsletters in English and Spanish were made available online (Feb 2013-May 2015)
- Data was collected and analyzed for quality improvements and reports, and these reports were given to LFAC (Feb 2013-Jun 2015)

Project Ending/Sustainability Plan

- Reviewed project process to develop best practice strategies (Mar 2013-Jun 2015)
- Press releases were developed to report on the project (Jan 2013-Jun 2015)
- Final reports written and shared with local elected officials (Jun 2015)

Additional details regarding project activities are as follows:

Over 3 school years (2012-2015), the HOTM program thrived and taught children, their parents and all members of the school community about California's specialty crops. Agriculture in the Classroom (AITC) and NCFB Managers outreached to growers and Sodexo Food Service to create produce calendars for the HOTM tastings. Seventeen specialty crops were featured over the three years, which were as follows: broccoli, snap peas, snow peas, English peas, strawberries, pears, apples, carrots, dried fruit, grapes, kiwis, red peppers, spinach, mandarins, kiwis, kale and radishes. Feedback from teachers, administrators, parents and students revealed positive impacts.

The grant team devised the delivery systems and outreached to all nineteen NVUSD elementary schools. Interest was originally strong and grew over the years, with 6,184 students in the program at the start of year one; 8,194 students in year two (+33%) and 8,365 in year three (+2% from prior year and +33% from year one). With the popularity of the program, enrollment continually grew and by year three HOTM served 337 classrooms at 19 school sites; only 1 classroom in the entire school district did not participate (99%+ participation).

Over 60 volunteers were recruited and trained to assist in the HOTM tasting kit preparations and the distribution at each school site. The volunteer base included enthusiastic parents and community members. The Napa Volunteer Center, Napa Police Department and Napa CanDo non-profit organizations provided extra support for the HOTM tastings that required more advanced preparation (i.e. kale salad).

Needed supplies/utensils were researched, purchased and delivered to the classrooms. 7,045 HOTM tasting kits were prepared and delivered, each with a teacher newsletter and Farmer of the Month (FOTM) print profile, and enough produce for each student and teacher to taste and discover the flavors, and learn about the nutritional value and farms where the produce was grown. The HOTM newsletters (in Spanish & English) were sent to parents in year one via each school's distribution system and in years two and three through NVUSD's Peachjar online e-flyer communications system.

Consistent with Objective One: Voice of the Farmer Project, twelve FOTM videos were produced, both in English and Spanish. The talent and skill of Spacious Economy Media (SEM), the videographer, provided succinct and entertaining videos of 2-3 minutes to educate the students about the farms where the HOTM featured produced was sourced. The videos created a connection to the farm. Total views over the grant period were over 15,000 and greatly exceeded the FOTM targets for viewing.

In year three, the Nutritionist/Chef hours were expanded to add an After School HOTM program and offer supplemental lessons to NVUSD classrooms and assemblies. The Nutritionist/Chef provided 53 additional classroom lessons to 2,685 students, 21 lessons to 400 students in the After School program, five cafeteria tasting for 1,035 students, and four special events for 1,650 kids.

Regular meetings were held with the grant team, stakeholders and collaborators to evaluate and improve the program. The meetings provided valuable info to ensure successful implementation, and remedy problems and barriers. Reports were provided regularly to the Local Food Advisory Council and each report generated much discussion and support.

Teacher surveys were conducted at the end of year 1 and twice per year in years 2 and 3. Feedback in each survey was very positive, with over 90% of the teachers raving about the program, and providing many suggestions. Student surveys were conducted in June 2013, May 2014 and May 2015. The student surveys indicated awareness of the nutritional value of fresh local produce and increased consumption. The difficulty in surveying the students was a surprise and a challenge. Nonetheless, the feedback indicated the program's effectiveness.

This project solely benefitted California specialty crops.

HOTM flourished with the ongoing assistance of the project partners. The key partners were NVUSD and Sodexo. Both remained committed to the program for the entire duration and despite some staff changes over the three years, the collaboration remained strong. NVUSD provided space at their central warehouse/kitchen to receive the HOTM produce. Sodexo incorporated the featured HOTM produce in their cafeteria service. Other partners included the Napa Agriculture Commissioner who provided assistance in contacting local growers and co-sponsoring a "Good Agricultural Practices" workshop for local growers, so they could qualify to sell to NVUSD. The Local Food Council provided support and feedback to the HOTM program. The volunteers provided invaluable assistance for the monthly operation of the HOTM tasting lessons.

Goals and Outcomes Achieved

Goal 1 – Increase student awareness of local farmers and specialty crops by bringing the "voice of the farmer" to students:

Spacious Economy Media was contracted to visit the Farmer of the Month sites, interview the farmers and create videos. Twelve videos were completed. Each video was also translated and produced in Spanish. In addition to the videos, each month a FOTM profile was created, printed and distributed to each classroom. The print profile was displayed on the classrooms' HOTM poster for the entire month. The teachers found the print material and FOTM videos effective in teaching agricultural literacy, commenting that "students love seeing the face behind their produce." Views of the FOTM videos greatly exceeded the targets.

HOTM succeeded in bridging a link between the classrooms and the farmers by utilizing multiple tools during the school year. The tools included FOTM posters & print profiles, FOTM videos and the HOTM lesson plans.

Baseline is zero Farmer of the Month video views; target was 2,250 views in year two and 2,475 views in year three.

Viewership numbers greatly surpassed the targets. In year two, YouTube tracking indicated average monthly FOTM views to be 4,258. Project staff assumed 80% of the YouTube views are by a classroom and 30 students per classroom. With improvements to the A/V classroom equipment, and popularity of the videos, the average FOTM views in year three increased to 7,483. Teacher survey comments on the FOTM videos included: "Kids loved the videos…made it real." "The videos are fabulous and very effective. In addition to the FOTM videos, FOTM print profiles were created and distributed. The teachers found the print material effective in teaching agricultural literacy, commenting that "students love seeing the face (farmer) behind their produce."

Goal 2 – Increase student consumption of local specialty crops by introducing local crops to students in the classroom:

From 2012-2015, 22 HOTM lessons and tasting experiences were provided to the students. Each experience taught students about the nutritional value of eating healthy local produce and was reinforced by the tastings of the fresh fruits and vegetables. The classroom tastings were followed by Sodexo serving the featured produce in the lunch service. Specialty crop consumption during both the classroom lesson and the lunch service continued to grow, with the student's eagerly looking forward to the next month's featured produce. The parent newsletters engaged the students' families and provided specialty crop recipes and nutritional information. Survey responses and feedback from parents and students indicated that the students requested the featured HOTM fruits and vegetables for their home meals. All HOTM team members and NVUSD staff contributed in conveying the consistent message of the benefits and value of eating local healthy produce.

Baseline: May 2013 student survey stats; target – 75% of the students surveyed report increased local produce consumption.

Students' consumption of local produce continued to increase due to the HOTM lessons' impact of introducing students to fresh California specialty crops. In May 2013, 50% of the students reported eating fruits and veggies every day while the May 2014 survey indicated 70% ate veggies daily and 83% ate fruit daily. By the third year, the May 2015 student survey reported 75% reported eating fresh fruits and vegetables every day. The enthusiastic response of the students to the tastings indicates an eagerness to try unfamiliar fresh California specialty crops.

Goal 3 – Partner with NVUSD and Sodexo to bring local produce (defined as within 200 mile radius of Napa) into school cafeterias:

From the beginning of the grant to the end, NVUSD, Sodexo and Freshpoint (Sodexo's produce vendor), actively supported the HOTM program. The grant team worked with the school staff to source the produce and to continue to purchase from the local vendor beyond the HOTM program needs. The grant team held several meetings with local growers to encourage participation in the program and held a "Good Agricultural Practices" certification workshop for growers. Freshpoint provided valuable assistance in sourcing and delivering locally sourced fruits and vegetables to serve in the HOTM program. The statistical increase in spending by Sodexo on local specialty crops from less than 20% at the start of the grant to 57% by the end validates the achievement of this goal.

Baseline – NVUSD spends less than 20% of produce spending on local produce; target is 20% increase annually.

Sodexo's Food Service Manager reports:

- Baseline Oct. 2012 - Local produce spending was less than 20%.
- End of grant school year 1 - Local produce spending was 41.75%.
- End of grant school year 2 - Local produce spending was increased to 47.78%.
- End of grant school year 3 – Local produce spending was increased to 57%.

Sodexo met the target after year 1, but felt a 6-7% increase in years 2 and 3 was more realistic. NVUSD and Sodexo continue to expand their farm-to-school strategies and remain a strong partner. NVUSD added a new Executive Chef to their Food Service team and began creating new menu options utilizing California specialty crops. In March 2015, NVUSD launched California Thursdays, which is collaboration with the Center for Ecoliteracy to serve healthy, freshly prepared school meals made from California-grown food. Like HOTM, California Thursdays supports local farmers while improving student health and academic achievement. HOTM has been the catalyst to expand the use of fresh produce in food service and improve nutrition and the quality of the food served to the students of Napa County. Sodexo remains committed to incorporating more locally grown specialty crops into their food service.

Goal 4 – Increase student knowledge of specialty crop nutrition through the HOTM program:
Student specialty crop nutrition education was a key segment of every HOTM tasting and FOTM video. Each month, grant staff gleaned the specialty crop nutritional information from the HOTM website and created and distributed the materials (teacher newsletter, parent newsletter, FOTM print profile and video) to the 337 classrooms. School administrators and teachers provided continual feedback to improve the program. Surveys were implemented annually to assess the improvement in specialty crop nutritional knowledge.

HOTM succeeded in teaching students about the nutritional value of California specialty crops and encouraged more consumption of the featured fresh produce. Teachers commented that students learned to make healthier food choices and the parents noted the nutrition charts in the parent newsletters as excellent information.

Baseline – May 2013 student survey; target – 75% increase in students' nutrition knowledge annually.

Progress towards the goal of improved nutrition is evident, as the May 2015 teacher online survey responses indicated that 96% of teachers stated that the HOTM program lessons were effective in teaching nutrition knowledge.

The grant team used survey questions sourced from the Network for a Healthy California, but establishing a baseline was difficult and the data does not fully describe the outcomes. The student surveys did indicate strong knowledge that eating fruits and vegetables helps them to grow healthy, smart and strong (97.8% in 2014 and 97.4% in 2015). Student survey responses in 2014 and 2015 indicated knowledge that eating fruits and vegetables will result in more energy, healthier skin, stronger eyes, better ability to think and healthier teeth and fewer cavities, with positive responses ranging from 72% to 98%.

Metrics to statistically track the increase in students' nutrition knowledge were difficult to determine. The thank you letters, testimonials from parents and feedback from the teachers, students and administrators reveal the successes. A few of the teacher survey comments were, "Many of my students shared the wonderful facts they learned in fitness during the lessons! It rocked!" and "The video, nutritional facts and recipes were great for teaching about the nutrition."

HOTM succeeded in teaching NVUSD elementary students about where and how their food is grown. Utilizing 22 FOTM print profiles and 12 FOTM videos provided a virtual visit to the farms where the featured HOTM fruits and vegetables were grown. Over 15,000 views of the FOTM videos were tracked and the videos remain posted online and continue to serve as effective agricultural literacy teaching tools.

8,365 NVUSD students in 337 classrooms at 19 school sites participated in the HOTM program and were introduced to 17 local specialty crops. They learned the nutritional value of the fruits and vegetables as well as recipes and serving suggestions for the produce. The fun and interactive HOTM program fostered increased student consumption of California specialty crops as well as increased knowledge regarding specialty crop nutrition.

Ag literacy outcome measures: Ag literacy targets were met and exceeded in years two and three. The first year stumbled, as the original contractor Cybermill was unable to provide the video production. FOTM print profiles filled the video void in year one. FOTM videos were produced and available at the start of year two, after exploring videographer options and contracting Spacious Economy Media. Estimated video views grew from 4,258 in 2013/2014 to 7,483 in 2014/2015 and greatly exceeded the targets.

Increased student consumption of local specialty crops: While the student survey instruments were difficult to administer, they do show evidence of increased consumption of local produce. Between June 2014 and May 2014, the percentage of students who responded they eat fruits and vegetables at school increased from 59% to 74%, an increase of 14%. More students in 2015 were willing to try new local specialty crops than in 2014 by a factor of 4%.

Bring local produce into school cafeterias: Progress was continually achieved in the long term outcome of increasing the amount Sodexo would spend on locally grown produce (within 200 miles). The baseline was <20% local spend in 2012. Sodexo reports local spend growth to 41% in 2013, 47% in 2014 and 57% in 2015.

Increased students' specialty crop nutritional knowledge: In the teacher survey of May 2015, 97% of the teachers felt that the HOTM lessons were effective in teaching students about nutrition. In the May 2015 student survey, 97.3% of the students replied yes to the question, "Does eating fresh fruits and vegetables make you strong, healthy and smart." That was an increase of 3% from the prior year.

Beneficiaries

Fifteen local growers who sold produce to NVUSD for HOTM directly benefited from this project. Additionally, NVUSD continued to purchase produce from the growers and increased their spending on local produce by 57% for a total of $229,186. Local growers gained access to the NVUSD's institutional purchasing powers. Hundreds of local growers in Napa County and counties close to Napa - Sonoma, Lake, Mendocino, Marin, Solano and Yolo, benefited by having their commodities highlighted by HOTM and enhancing their opportunity to be a produce source for Sodexo and Fresh Point. NVUSD and Sodexo found a ready and able partner in improving their food service.

NVUSD students and their families gained awareness of the diversity of California specialty crops, knowledge of the nutritional value, insights about farming practices and an appreciation of the appealing fresh flavors of locally grown produce. 8,365 NVUSD elementary students and their families benefited from the HOTM program as well; with an average household size of 2.7, the reach is estimated at 22,586 people. 337 teachers and 19 principals benefited by having free access to the HOTM materials and produce for their schools. The entire Napa community may benefit by having reduced health care costs and the improved learning ability resulting from students' healthier eating habits.

Lessons Learned

With the broad reach of the HOTM program, flexibility at each school site and in many cases each classroom was key to gaining full engagement by the school staff in implementing the tastings. Project staff quickly learned the severe time constraints of teachers and provided as much support as possible to assist with monthly produce tastings. Ease of preparation for the tasting lesson was a key factor, but the extra effort needed to introduce unfamiliar produce such as kale, was warranted by the positive impact of kids loving kale salad.

As noted in the benchmark/target questions, the survey tools for students were challenging. Creating questions that children can easily comprehend and gaining support from the teachers in implementing the survey in a consistent manner will improve this reporting mechanism. With the vagaries of weather and farming factors, there were many instances of last minute switches in the type, size or sourcing of the produce. Adaptability and deeper communication with both the produce vendor and farmer helped alleviate the stress and extra costs of receiving unexpected produce substitutes.

An unexpected and totally opportune outcome was the catalyst of HOTM to bring a "new wave of thinking" to NVUSD's food service and the synergy of working collaboratively to create healthier food choices and access additional grants and resources to create new menus and recipes using fresh locally grown produce and less processed foods. In concert with NVUSD's Wellness Committee, Sodexo and the Food Service leaders hired a new Executive Chef and implemented taste testing and focus groups with students to insure the students would eat the local produce served in the meal program.

The reach of the HOTM program beyond the school setting also surprised the grant team. Students enjoyed the HOTM tasting and cooking lessons immensely and brought the enthusiasm about the delicious specialty crops to their families and friends.

While the grant succeeded in bringing fifteen local growers into the NVUSD food service purchasing system, project staff were unable to utilize Napa County growers as a local source. With Napa County's predominant crop being wine grapes (99% of the county's crop value), the diversified growers are generally small, unwilling to deal with NVUSD's grower requirements and unable to supply the large quantities needed to supply the produce for the monthly tastings. Efforts to create joint ventures with multiple growers to combine their production and meet the demand, proved too complex. Grant staff continued to keep Napa growers informed about HOTM, and sourced local produce from within 200 miles of Napa. In year one, average distance of the featured farm was 161 miles, in year two 85 miles and in year three 117 miles.

Additional Information

The Farmer of the Month videos can be accessed at http://www.napafarmbureau.org/videos.html.

Additional information in the attached appendices includes:

1. HOTM photo collage, FOTM video tracking summary 2014/15, HOTM School Enrollment chart 2014/15, and summary of Sodexo's local produce spending for 2014/2015
2. Student and teacher surveys

USDA Project No.: 33	Project Title: Building vertically integrated, community owned fresh foods enterprise networks	
Grant Recipient: People United For a Better Life in Oakland	**Grant Agreement No.:** SCB12033	**Date Submitted:** December 2014
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Project Summary

California's specialty crop producers face a common set of interlinked, mutually-reinforcing threats: (1) growth-related development pressures; (2) removal of lands from production due to resource limits, primarily competing water uses and habitat protection mandates; (3) alarming decline in the number of skilled farmers; and (4) inaccessibility of markets for emerging small-scale producers due to incomplete retail/distribution networks, resulting from industry consolidation and institutional barriers to small business development, especially in low-income areas. Farm income is in steady decline even as productivity gradually increases. Although California consumers spend $66 billion on food each year, the net outflow of income from farms is over $10 billion, nearly half the entire value of the state's food crops. As direct relationships between producer and consumer vanish, wealth aggregates to the entities that control the steps in a lengthening supply chain. Although recent market research shows three-quarters of consumers are intentionally seeking to buy local products, less than 0.5% of statewide farm income ($114 million) comes from direct sales to consumers. The most profitable agricultural counties are those close to urban areas, which are losing land most rapidly to development and preservation. To strengthen farm-based economies, agricultural lands near cities must be recognized as a public resource as well as an environmental asset. Operating as isolated entities, local food enterprises struggle to gain economic footholds; integrating them in linked, place-based networks ensures long-term viability.

Of the 20 million acres of farmland within 100 miles of the Bay Area, the 18% that is dedicated to specialty crops accounts for 75% of the total economic value. Investments into building local systems have a high impact due to the Bay Area's economic weight, the density and diversity of communities, and the extensive nearby base of productive but imperiled farmlands. By opening up conserved public lands and ecologically sensitive areas for sustainable production, this project worked to establish support for local specialty crop economies, enabled 250 underemployed residents to develop specialty crop enterprises, expanded direct sales beyond elite "niches" into under-served urban markets (20,000 residents), and carried out highly visible public education programs. The successes of this project help to support the sustainability of specialty crop enterprises statewide.

This project does not build upon a previously funded Specialty Crop Block Grant Program (SCBGP) project.

Project Approach

The activities performed are outlined below:

Finalize production and sales plans, ecological restoration strategies

- The crop production plans, retail food business plans, and ecological restoration strategies that were developed as part of this project represent valuable information resources, and this knowledge has been shared extensively though education and employment training programs at local community colleges and high schools. The agricultural production projects taking place are precedent-setting for the four public land management agencies who are partnering with PUEBLO (People United for a Better Life in Oakland), and their success is enabling expanded opportunities for disadvantaged farmers and ecologically restorative farming. In addition, these farming projects supported four new ongoing training programs, operated in conjunction with public high schools and community colleges.

Expand direct retail marketing through existing networks (produce stands, farmers markets, Community Supported Agriculture or CSA's) to align to production; operate integrated production/retail system at school/community sites in under-served areas; negotiate sales contracts with partner institutions (schools, colleges, hospital) and operate retail sales program

- During the reporting period, Phat Beets Produce and PUEBLO operated two weekly farmers' markets, six weekly produce stands (four school-based, two hospital/clinic-based), and a 300-member CSA in underserved areas of Oakland, in conjunction with public schools and health centers. Phat Beets Produce and PUEBLO's direct-to-consumer retail development has created new sales outlets for two urban farms, three peri-urban farms, and five rural farms, operated by farmers of disadvantaged or refugee backgrounds, that grow pesticide free and organic produce in the local area. In addition, Phat Beets Produce provided produce for a local juicing company, a catering company, a local restaurant, Children's Hospital, and four prepared food retail businesses that have been opened through the project's training programs. PUEBLO's produce sales programs supplied monthly lunches/dinners (to Castlemont High School) and weekly after-school healthy meals for high school students of low-income families, as well as 15-20 large school and community events in East Oakland each year. Over the project period, partners increased total retail sales over 250%, while opening five new locations and expanding into two new neighborhoods, providing affordable organic/pesticide free specialty crops for several thousand low income residents each week.

Finalize farmer production training course curriculum; enroll participants; begin fresh food enterprise training course; begin farmer production training courses; hold one training each month

- Throughout the project period, project staff (from International Rescue Committee (IRC), PUEBLO, and Phat Beets) developed and taught training courses in agricultural production and fresh food business developments for disadvantaged Oakland residents. These courses took place through public high schools, community colleges, refugee resettlement programs, and youth job-training programs. During the project period, over 400 low-income residents took part in these training courses, many of whom have gained employment or started businesses.

Prepare farm tours program; conduct outreach to schools; begin farm tours program and public education programs

- PUEBLO and Phat Beets developed and operated school-based education programs promoting the consumption of specialty crops through cooking, tasting, farm tours, and other hands-on activities, involving over 2,800 students at twenty-four public schools, churches, and clinics. Several of these institutions have since incorporated specialty crop education into their ongoing academic programming.

All of the retail sales programs (farmers' markets, CSA, produce stands) consist entirely of specialty crops and specialty crop products. Therefore, SCBG funds that assisted the operation of those retail sales programs were solely used to enhance the competitiveness of specialty crops. All retail sales activities are supervised by the Retail Manager, who manages the farmers markets/produce stands, and purchases all products sold through the CSA exclusively from the local specialty crop farmers who sell at these markets. All of PUEBLO's, Phat Beets' and IRC's education and training programs focused entirely on promoting increased production and consumption of specialty crops.

Program income was used to develop marketing infrastructure for small disadvantaged farmers in the network, who are producing only specialty crops. The project directors worked closely with these farmers throughout the project period for developing marketing and sales strategies.

PUEBLO operated school produce stand retail outlets, public education programs, and school-based employment/enterprise training programs in East Oakland neighborhoods. PUEBLO helped to secure land use agreements with public agencies (Oakland Parks & Recreation, East Bay Municipal Utilities District, Peralta Colleges, Oakland Unified Schools) used for farming by disadvantaged farmers and for school tours/public education programs. PUEBLO's Project Director, working in conjunction with Peralta Colleges, developed and taught new courses in urban agro-ecology, small-scale agricultural production, and fresh food enterprise development for low-income Oakland residents. International Rescue Committee and resettlement partners developed and operated a "New Roots" program for new Oakland residents (primarily of refugee status), providing training in agricultural production, access to free land and markets, business development assistance, and public education programs promoting specialty crops. Phat Beets Produce operated school produce stands, community farmers' markets, a CSA, a retail sales development program, and fresh food business development programs for youth and disadvantaged residents, as well as organizing public education/community events in North Oakland neighborhoods to promote specialty crops and products.

Goals and Outcomes Achieved

The goals and outcomes during the project term are outlined below:

1. Public lands agriculture: When the groundwater supply for the initial project site proved unreliable, PUEBLO and partners changed production plans at that site, while negotiating three additional public land sites to carry out the program. Although these decisions reduced the initial acreage and production levels by approximately one-third, two of these new sites were better adapted for training, education, and marketing due to their convenient locations at urban school/college campuses. In addition, the success of these projects has opened up additional opportunities for specialty crop agriculture on urban public lands, as two of the projects have been approved for significant expansion. For example, the three project partners have assembled a coalition (the Edible Parks Task Force) that negotiated a Memorandum of Understanding between PUEBLO and the City of Oakland opening up all city parks to community-based agriculture. Meanwhile, the low-water production strategies being developed at the original site are providing insight into farming approaches for limited water situations, while still creating enterprise and agro-tourism opportunities for new farming businesses serving disadvantaged populations. The project's public agency partner approved an expansion of the original project to additional acreage nearby.

2. Fresh Food Enterprises in under-served markets: PUEBLO and Phat Beets operated seven farmer-to-consumer retail outlets (produce stands, farmers' markets, and a CSA) at clinics, hospitals, and public schools in two of Oakland's most underserved retail neighborhoods. In addition, an expanded retail sales program began pilot sales programs at colleges, public schools, and hospitals. Using the sales records

compiled by retail and education/promotions staff, project partners estimate that over the course of the project period, retail sales and education/promotion programs provided affordable organic specialty crops to 16,000 Oakland residents in under-served areas. Project partners estimate that the project distributed 8-9,000 pounds of specialty crops to school and hospitals/clinic food service departments over the project period. PUEBLO increased sales opportunities by working with other retail markets including locally owned supermarkets, online retailers, restaurants, stores, and small food processors. Through these sales channels, the project team distributed an additional 28,000 pounds of specialty crops grown by disadvantaged farmers in our network. The lack of cold storage limited the ability to distribute products to large institutions.

3. Training and public education programs: PUEBLO, Phat Beets, and IRC developed and operated fresh food enterprise training programs serving over 400 underemployed Oakland residents, creating new businesses in the production, preparation, processing, and sales of specialty crops. Project partners' urban agriculture and food systems classes, hands-on education programs, and farm tours, carried out in 15 public schools and two community colleges, directly linked over 5,800 Oakland residents of under-served markets to fresh, local foods each year.

All programs the project initiated (training and business development programs, education classes, farm tours, retail sales businesses, and ecologically restorative agriculture on public lands) have grown steadily since inception, due to increasing support from both community residents and partner institutions. Since the project began, sales levels and market opportunities have increased significantly. Because of this, project partners anticipate continued expansion, and increased training and education programs over the long term.

- Production – Site 1 (Laney) – 15,000 pounds production (est.); Site 2 (School/Oakland Parks and Recreation or OPR) – 6,000 pounds production (est.); Site 3 & 4 (EBMUD/peri-urban) – 45,000 pounds production. Total 66,000 pounds production on 7.5 total acres.
- Retail sales/distribution – East Oakland school produce stands (3) – $40,000 sales organic specialty crops; North Oakland school produce stands (3) - $12,000 sales organic specialty crops; North Oakland farmers' markets (2) and CSA - $150,000 sales organic specialty crops; sales to institutions and retailers - $48,000.
- Total estimated $250,000 retail sales and distribution.

The major successful outcomes of the project are outlined below:

- Increased sales volume by 225% during the project period, resulting in a total of approximately $250,000 in specialty crop retail sales in underserved neighborhoods.
- Project partners provided training courses, technical assistance, and opportunities in fresh food enterprise development for 440 disadvantaged Oakland residents.
- Provided specialty crop education programs/events and farm tours for approximately 5800 residents of low-income Oakland neighborhoods.
- Secured agricultural land use agreements with four public land management agencies (totaling eighteen acres of urban and peri-urban land), providing specialty crop production opportunities for 75 disadvantaged farmers, and hosting new education/training programs with four public education institutions.

Beneficiaries

A description of beneficiaries as a result of this project's accomplishments is outlined below:

1) Provided over 60 Oakland residents of refugee status with public land on which to grow and sell specialty crops to markets in their own neighborhoods, in collaboration with two refugee resettlement agencies;
2) Provided over 400 disadvantaged, low-income Oakland residents with training and business development opportunities in the growing, preparing, and sales of specialty crop foods, in collaboration with public high schools in East Oakland, community colleges, youth training programs, family support organizations, and refugee resettlement agencies;
3) Provided over 2,800 K-12 students in 15 East Oakland and North Oakland public schools with hands-on education programs and farm tours;
4) Provided improved access to affordable, organic/pesticide free specialty crops for an estimated 16,000 residents of Oakland neighborhoods severely lacking in food retail; and
5) Provided improved access to retail markets for 45 disadvantaged farmers, many of refugee status, through direct farm-to-consumer retail and institutional sales opportunities. Total economic benefit to disadvantaged producers equaled approximately $250,000 in income.

All of the measurable outcomes described were of exclusive benefit to California specialty crops.

Lessons Learned

Managing the project as a coalition of partners enabled project partners: 1) to draw on their respective strengths (education, training, and retail); 2) to directly reach residents in the different areas of the city where the organizations' presence was strongest; 3) to build relationships with a variety of institutional partners; 4) to increase economic opportunity by linking small food enterprises in an allied network; and 5) to leverage additional resources that project partners could dedicate towards the goals. In addition, partnerships with public agencies enabled project partners to access land resources for beneficial purposes and establish successful models; in low-income neighborhoods, public resources, such as parks and schools, are often the community's most significant and secure assets, but often they are highly underutilized due to barriers to participation.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 34	**Project Title:** Cultivating Community Advocates	
Grant Recipient: Friends of Independent Living Services of Northern California	**Grant Agreement No.:** SBC12034	**Date Submitted:** December 2015
Recipient Contact: evanlevang@ilsnc.org	**Telephone:** 530-680-3484	**Email:** contact@ccadvocates.org

Grant Award Amount (A)	Amount Invoiced to Date (B)	Remaining Grant Balance (A-B)	Program Income	Committed Match/In-Kind Funds	Match/In-Kind Funds Utilized to Date
$400,000	$398,344.05	$1,655.95	$6,300	$0	$0

Project Summary

A 2011 Specialty Crop Block Grant Program project aiming to increase local organic specialty crop growing/access among low-income, student and small farmer populations successfully engaged students and gardening enthusiasts. However, there was difficulty reaching more diverse populations facing obstacles in addition to low-income status – language barriers, physical/developmental disabilities, homelessness, mental illness, cultural/geographic isolation. To address this difficulty, Friends of Independent Living Services (F-ILSNC) developed a training and funding program structured to put resources, in the form of competitive subgrant awards, directly into the hands of populations most in need. Subgrantees would award specialty crop projects designed by applicants in cooperation with members of a target population, addressing the unique needs of that target population. A mandatory networking and training component was added, designed to (1) facilitate leadership within access-challenged populations with a horizontal learning-community structure; (2) train subgrant leaders in community organization & grant management; (3) build a culture of skill & resource-sharing.

Sixty percent of Butte County's resident population suffers from diet-related illness, and 31% faces increasing food insecurity in 23 urban/rural food deserts. Over-represented in these percentages are low-income residents with exceptional cultural, physical, developmental, legal or geographic barriers restricting their capacity to fully engage the specialty crop economy. Cultivating Community Advocates (CCA) was structured to directly help these populations to participate in the specialty crop economy as producers as well as consumers, while supporting served members in exerting maximum control over resources and project design.

While not specifically building upon a previous Specialty Crop Block Grant Program (SCBGP) project, this project was a pilot project that complemented 2011 SCBGP Project 48: *Cultivating a Community Nutritional Health Network.*

Project Approach

(1) Task: Convened CCA's multi-agency Stakeholder Coalition tri-annually.
Accomplished: Eight times throughout the project period, CCA convened its tri-annual Stakeholder Coalition of 20-plus collaborators, beneficiaries and advisors from educational, help-agency and farming sectors to organize shared visions, identify community needs, strategize and cross-promote efforts, avoid service

overlap, troubleshoot, network, guide future steps, share achievements, disseminate and analyze project results, examine obstacles and plan for project sustainability.
(2) Task: Provided Specialty Crop Training & Learning Community (TLC) sessions.
Accomplished: For Rounds 1, 2 and 3 subgrantees, CCA's Project Coordinator provided four weeks of required intensive two-hour Tier-1 TLC training sessions immediately following award, then monthly two-hour Tier-1 TLC mandatory sessions throughout the course of each of each subgrantee project.
(3) Task: Project Coordinator oversaw & assisted with Tier 2 (within/for sub-project target communities) monthly specialty crop meetings/events throughout the course of each sub-project.
Accomplished: CCA's Program Coordinator assisted sub-projects with specialty crop-based Tier-2 learning community events, and provided further support as needed to all subgrantees: with strategic planning, visioning, event organization and implementation.
(4) Task: Project Coordinator tracked participation, data and project compliance of Tier 2 events.
Accomplished: Throughout the course of the greater project, CCA's Project Coordinator met bimonthly with each of all three rounds of individual subgrantee leads until projects were completed, to examine goal achievement, record deliverables, assess specialty crop compliance in mini-grant budgets, activities and promotional language, and to troubleshoot problems. The Project Coordinator also made an average of two evaluative visits to each project site. The Project Coordinator collected sub-grant project progress reports at every Tier-1 TLC meeting, and reviewed participant surveys where applicable.
(5) Task: Management Team awarded and oversaw three unique rounds of sub-grants.
Accomplished: Three rounds of subgrant projects were solicited, reviewed and awarded in April 2013 (five awards), November 2013 (three awards), and April 2014 (five new awards, five partial renewals).
(6) Task: CCA's Management Team supported successful implementation of sub-grant projects.
Accomplished: Below are Final Report Summaries for sub-projects from Round 1 (awarded April 2013), Round 2 (Awarded November 2013) and Round 3 (Awarded April 2014):

(a) Round 1, with partial renewal. Westside Domestic Violence Shelter (WSDVS) (Invoiced: $14,500; Timeframe: April 2013-June 2015): WSDVS's project put in a .25 acre vegetable garden and revitalized a 2-acre citrus orchard to be maintained by staff and shelter guests. Project leaders held 65 nutrition/cooking classes featuring produce from the WSDVS garden and orchard, serving 215 residents in the course of the project. WSDVS staff also held 16 garden workshops with shelter residents, involving 75 total unique participants. WSDVS's garden and orchard continue to thrive under the care of shelter staff and residents.

(b) Round 1, with partial renewal. Jarvis Gardens Senior Project (JGSP) (Invoiced: $14,000; Timeframe: April 2013-June 2015): JGSP's project put in a .3 acre vegetable garden and 16 fruit trees, which supplied the low-income, HUD-subsidized senior facility with fresh produce and the opportunity for its occupants to garden and learn about gardening. The JGSP project created a garden planning committee which met weekly for a total of 50 meetings (37 members and 189 sign-ins). 62 residents devoted 2,319 hours to planting, maintaining and harvesting the farmsite year-round. JGSP also hosted six community garden workshop/events teaching garden bed preparation, fruit tree planting, fruit tree pruning, and increasing garden accessibility, with 55 participants. JGSP also held 13 bi-monthly from-the-garden potluck activities involving all facility residents, and held six specialty crop nutrition classes with 19 participants. Harvest was utilized in facility meals, and distributed via share-boxes, with costs determined according to box size and work contributions. JGSP's program income of $840 was re-invested into garden supplies.

(c) Round 1, with partial renewal "Maker's Garden Project," Chico (Invoiced: $16,000; Timeframe: April 2013-June 2015): Second Baptist's Maker's Garden Project (MGP) created a .5 acre farmsite on the grounds of its mostly African-American and Latino church located in an impoverished neighborhood in Chico, California. MGP's team held weekly farmsite workdays in two-hour slots, averaging three unique and eoght total participants per week. Forty-two congregation members invested a collective 1,186 hours in garden planting, upkeep and harvest. MGP hosted eight events: two spring planting weekends with 50 volunteers; two harvest events, two workshops teaching strawberry replanting, building garden rows, and two pickling and produce drying workshops (182 sign-ins). MGP built a work-exchange-based CSA program with 26 members, and also built a farmstand from which church youth sold garden produce on Saturdays at nearby soccer games. MGP's harvest included kale, tomatoes, squash, cucumber, onions, bell peppers, okra, pumpkins, carrots, strawberries, peas, eggplant, peppers, mint, collard greens, lettuce, cabbage, and rosemary. MGP's program income of $760 was re-invested into garden supplies.

(d) Round 1, Love Chapmantown Farmer's Market: Good Food Now! (LCGFN!) (Invoiced: $14,000; Timeframe: April 2013-June 2015): Serving an unincorporated barrio within the greater city of Chico with a high immigrant, nonwhite, and low-income population, LCGFN! worked to eliminate a local food desert by launching a comprehensive healthy/local food promotion and outreach program in support of building a small neighborhood farmers market. In the project period LCGFN! held 50 farmer's market events with an average of four to six neighborhood specialty crop vendors, drawing 130-plus customers per market day. The market hosted 11 bi-monthly educational/festival events featuring nine culinary demos/tastings with a bike-powered kitchen featuring the produce of market vendors. Festivals averaged 200 participants per event, as measured by raffle tickets, gate counts and vendor reports. LCGFN! also organized 12 bi-monthly vendor's meetings to address concerns, share farmer's market information, outreach strategies, market goals, budget updates and to build sustainability, including implementing stall fees at 10% of market day income. An estimated 6,500 non-unique participants attended LCGFN!'s market-based events, with attendance showing an 83% increase and profits showing a 118% increase from April 2013 to June 2015, and a doubling of vendors from an average of three to an average of six (depending on season). Approximately $30,000 of business been generated over the course of the project; $1,000 in revenue from stall fees, which has been re-invested into the market's management. A large LCGFN!-sponsored event drew over 200 Tier 2 participants.

(e) Round 1, African American Family & Cultural Center Garden. (Invoiced: $17,000; Timeframe: April 2013-June 2015): The AAFCC project installed a .5 acre garden in an impoverished, high-stress neighborhood in Southside Oroville to promote community connections, healthy eating, and specialty crop growing skills among neighborhood residents. Project participants maintained 10 farming hours average per week among four to six volunteers (150 hours per month). AAFCC's team hosted bi-monthly garden workshops/workdays, each with a skill-building theme, e.g., building soil, vermicomposting, seed starting, seed saving, planting a spring garden, how/when to harvest leafy and root vegetables, planting and pruning fruit trees, and farming-for-fitness, drawing 260 unique participants. The AAFCC farmsite also hosted an Oroville Food Day Pumpkinfest event, drawing 230-plus participants. AAFCC's garden produced voluminously year-round. A large AAFCC-sponsored event drew over 200 Tier 2 participants.

(f) Round 2, Catalyst Domestic Violence Shelter Project (Invoiced: $8,127; Timeframe: November 2013-October 2014): Catalyst's year-long Nutrition Project provided biweekly workshop-style educational culinary demonstrations featuring specialty crops, and provided specialty crop-based meals for 48 unique adult shelter resident participants. Catalyst's project implemented 28 instructional events, serving 95 unique participants (including children), totaling 148 educational units.

(g) Round 2, The Jesus Center Farm Project (JCFP) (Invoiced: $9,331; Timeframe: November 2013-November 2014): JCFP installed a two-acre vegetable farm and used the site as a platform to train 150 homeless and JobLink-referred residents in food-growing and farm sales. Participants logged 1,525 food-production hours and grew 7,812 lbs. of vegetables, generating $3,700 in farmstand sales and donations, which was re-invested into the training program. The farm has achieved sustainability, generating $200-$300 per week, and continues its homeless resident farmer training program on its two-acre vegetable garden plot. Five interns graduated from JCFP's master farmer program and have transitioned into paying farm jobs.

(h) Round 2: Work Training Center Project (WTC) (Invoiced: $8,989; Timeline: November 2013-October 2014): WTC's team installed a .25 acre vegetable, fruit and floriculture garden and three-phase composting system which served, and was maintained by, WTC's developmentally disabled clients. WTC's project averaged 5-10 clients working in the garden daily, with 43 unique participants, totaling 5,916 project hours, 1,300 educational units and 5,925 facility meals supplemented by WTC's fruit and vegetable harvest. Clients participated in all aspects of specialty crop growing—planting, weeding, watering, and harvesting.

(i) Round 3: Berry Creek Educational Garden Project (BCGP) (Invoiced: $5,400; Timeframe: April 2014-March 2015): BCGP put in a .3-acre vegetable & fruit planted farmsite, and hosted 35 garden-based instructional events for 62 unique student/community participants, with 144 sign-ins. The farmsite grew 500 pounds of berries, vegetables, and herbs, which was made available to participating students and their families.

(j) Round 3: Paradise Elementary School Garden Project (Invoiced: $13,460; Timeframe: April 2014-June 2015): Paradise Garden Project's team used its farmsite of fruit trees and vegetable plants to provide 4,090 educational units and 188 unique garden education classes to 220 students and staff for a total of 230 participants. Instructional topics included water-saving irrigation techniques like flood, sprinkler and drip line, soil enhancement, when to harvest, seeding, transplanting, and seed saving. Paradise Elementary's Garden grew an estimated 3,000 pounds of specialty crops such as lettuce, chard, kale, broccoli, snow peas, carrots, cabbage, brussel sprouts, cauliflower, tomatoes, peppers, eggplant, sunflowers, basil, beans, tomatillos, all consumed by students.

(k) Round 3: Concow Elementary Garden Project (Invoiced: $8,964; Timeline: April 2014-June 2015): Gratitude Garden's team, which serves a low-income rural school in the Sierra Nevada foothills, put in a .3 acre diverse, bio-intensive vegetable and berry garden, and trained students in soil building, planting, farm support and harvest. Students from six K-8 classes shared 45-minute rotating farm-to-fork garden lessons during the school year. More than 143 unique K-8 students participated in 253 school-based gardening classes, and bi-monthly weekend family garden workdays drew 48 unique family participants (169 sign-ins) for a total of 3,949-plus educational units for the project. Approximately 1,050 pounds of produce was harvested and tasted/consumed by students as part of their gardening instruction experience.

(l) Round 3: GRUB Education Project (Invoiced: $8,100; Timeframe: April-2014-June 2015): GRUB's farming and community-organizing team provided consultation, visioning, troubleshooting and planning support to 10 different CCA sub-project grantee leads who requested assistance. GRUB Education assisted with the planning and implementation of 32 sub-project events, including community work days, training with shading mechanisms, and building farm stands for neighborhood sales, which drew 153 unique Tier 1 and Tier 2 participants.

(m) Round 3: The Veteran's Garden Project (VGP) (Award: $1,000; Timeframe: April 2014-September 2014): The Veterans Garden Project (VGP) grew vegetable starts, and put in an organic vegetable and fruit tree farmsite to be cooperatively maintained by local veterans as part of a peer-support program. On Memorial Day 2014, 2,000 starts were provided to 200-plus veteran families. From June-September 2014, the Veterans Garden Project held a total of 16 weekly two-hour garden events totaling 29 unique participants and 96 educational units. Monthly from June-September 2014, VGP held two-hour Healthy Kitchen Teaching Workshops using produce harvested from the Veterans Garden. These workshops averaged nine participants, totaling 38 total educational units and 16 total unique participants.

CCA and its funded subprojects benefitted no commodities other than specialty crops. To ensure grant funds only benefited specialty crops, all farmers market activities associated were carefully monitored by the project management team, subgrantees award contracts stipulated exclusively specialty crop-based activities, subgrantees were required to submit reports for review of achievement of targets and specialty crop compliance, and promotional materials and language, independent contractor documents, and budgets were reviewed for specialty crop compliance.

Supporting partners and stakeholders of the project, including California State University (CSU), Chico's Cultivating Healthy Communities program, CSU Chico's Organic Vegetable Project, the Northern California Regional Land Trust, CSU Chico's Edible Pedal Project and CalFresh Outreach provided consultation, promotion, and guidance at no cost, as well as nutritional and culinary educational presentations and farming workshops both to subgrantee leads and to served subproject communities. Donors of garden labor included parent groups, local Boy Scout Association troops, CSU Chico's Habitat Group, CSU Chico's CATS in the Community student volunteers, and volunteers from Trinity United Methodist Church, the SkyCreek Dharma Center, Love Chapmantown Community Coalition, and Chico Peace & Justice Center. Donors of farming materials included the Re-Store and Habitat for Humanity. Donors of event promotion materials and meeting resources included the Chico News & Review, KZFR Radio, Hungry Wildcat Student Services, Butte County Community & Economic Development, From the Ground Up Farms, Butte County Public Health, North Valley Food Hub, Chico Area Recreation District School Garden Programs, the Respectful Revolution Project, Southside Chico Farmer's Market, CSU Chico's The Chico Grange, Chico's East Avenue Church, Butte County Department of Probation, the Disability Action Center, and CSU Chico's Certified Farmer's Market, School of Agriculture, Department of Nutrition & Food Sciences, Geology Department, Center for Regional & Continuing Education, "Veggie Bucks" Program, and Associated Students Sustainability Program.

Goals and Outcomes Achieved

To achieve increased networking capability and response capacity, CCA formed a stakeholder coalition of over 70 members, with core members representing 20 organizations attending all eight meetings.

To achieve the goal of increasing competitiveness of, and participation in, the specialty crop economy within target populations, CCA's project leads awarded $141,000 in three funding rounds to 13 sub-projects. These sub-projects were implemented by community groups/organizations committed to supporting participation in the specialty crop economy by helping participants become producers as well as consumers.

To insure performance targets of 500+ unique target population members showing increased participation in specialty crop-promoting nutritional/educational activities, CCA's Management Team awarded a diversity of projects, including some with institutionally supported/required participation—e.g., two elementary school garden projects with several classrooms of students participating as part of their regular school day; two domestic violence shelters and a Work Training Center for the developmentally disabled, with target population members already in residence, with participation built into facility programs.

To achieve the goal of increasing participant-community capacity to provide for members' nutritional and food system needs, CCA provided weekly, then monthly, intensive training both in farming techniques and in community organization to grantees. This mandatory training component was designed to help subgrantees engage their served community members in specialty crop consumption, preparation, cultivation and sale, and to cooperatively build a culture of inter-project networking and shared knowledge. Trainings were also designed to assist subgrantees in strengthening their projects' administrative/organizational credibility toward building project sustainability.

CCA surveys measuring local specialty crop activity in general, and also following CCA event attendance, show that habitual specialty crop purchase, consumption, preparation, preservation, cultivation and sale rose significantly as a function project participation.

Ongoing specialty crop growing as a result of CCA's project is expected to produce an average $20,000 worth of crops per year ($200,000 over the next ten years – 5.5 acres producing an estimated average of $3,636 worth each of produce/year. This amount is just over half the estimated production derived from a 2008 U.S. Department of Agriculture National Agriculture Statistics Service study ratio of 3,100 acres of specialty crops with a production value of $20 million = $6,451 per acre). Increase in reported specialty crop purchasing and consumption in target population members is expected to continue, adding an additional economic effect of more than $200,000/year ($8.40/month average. increase in specialty crop purchasing per participant).

The summary analysis of CCA's Local Specialty Crop Activity Survey & CCA's Longitudinal Survey indicates that habitual consumption of specialty crops has increased among CCA participants in relation to the frequency of attendance at CCA events and workshops. The health benefits associated with consumption of fruits and vegetables is well-documented (e.g., X. Wang, et. al, British Medical Journal 2014), and increased specialty crop consumption is correlated with improved health. Thus, a significant degree of health benefits enjoyed by CCA participants may be realistically attributed to the project.

CCA's target goals may be summarized by the following: (A) increased competitiveness of the specialty crop economy within target populations; (B) increased reach/scope of local agriculture projects; (C) increased participation in the specialty crop economy among the access-challenged; (D) increased target participant capacity to provide for own nutritional/food system needs.

Target 1: All grantees receive intensive weekly, then monthly, training in community organizing and farming methods. Actual: All training sessions were held and attended as planned.

Target 2: 7-10 distinct access-challenged populations served with monthly Tier 2 specialty crop based training & learning community (T-2 SC-TLC) meetings/events. Actual: October 2014-March 2015, all sub-project leaders held monthly T-2 SC-TLC events among 12 distinct served populations.

Target 3: 7-10 distinct access-challenged populations served by competitively awarded specialty crop-based subgrant projects. Actual: CCA exceeded this objective, awarding 13 projects.

Target 4: 500+ unique target population members would show increased participation in specialty crop-promoting nutritional/educational activities. Actual: In aggregate, this objective continues to be exceeded at the CCA project level by 300%. To-date cumulative totals for all funded sub-projects: 2,000 unique participants, 12,000-plus educational units, 15,000-plus hours of specialty crop-based activity.

Target 5: By 2015, a 5%+ increase in cultivation of specialty crops. Actual: Subgrant recipient organizations had very little cultivation activity prior to this project (baseline near zero). Subgrant projects added 10 farmsites on 5.5 acres.

Target 6: Longitudinal change in a minimum of 30% of participants showing substantially increased specialty crop cultivation, marketing and consumption following project participation. Actual: Longitudinal surveys completed by a representative sample of participants (165) showed that specialty crop activity increased as a function of project participation. (The following figures reflect the percentage of participants indicating that they now perform more of each specialty crop activity after project participation: Cultivation: 58%; Preparation: 93%; Purchase 52%; Consumption: 57%; Sales: 10%

Note: Participant reports of "specialty crop sales" fell beneath the targeted 30% of participants reporting an increase in their specialty crop sales activity. However, many CCA sub-projects grew specialty crops to feed in-house served members (e.g., at Jarvis Gardens Senior Apartments and Work Training Center), with grown food provided in exchange for work/time, or provided as a part of an educational or skill-building process (e.g., in school gardens). Few funded subprojects had "outside sales" as an objective, but instead had the objective of self-sustainability through the collective growing and eating of specialty crops with shared efforts. For the projects that did focus upon sales – e.g., Jesus Center Farm project and Love Chapmantown Good Food Now farmer's market, sales increases were significant (e.g., for the farmer's market, manager reported an average 118% increase in sales over-baseline in the project period), and Jesus Center Farm averaged (and still averages) $250 per week year-round, from a baseline of zero.

CCA's project has achieved a successful demonstration model encompassing partnerships with service agencies, farmer networks, conservation organizations, neighborhood revitalization groups and schools. CCA has also developed substantial specialty crop industry-supporting capacity, as evidenced by:

1. Over 2,000 unique participants – agriculture students, and low-income residents having increased knowledge/skill to prepare, buy and sell specialty crops, and to cultivate them in diverse environments.
2. More than 10 new growers direct-marketing or directly serving target populations in local food deserts.
3. 5.5 active acres on 10 urban/rural sites, collectively producing over $20,000/year worth of specialty crops annually supplying two shelters, one senior-support agency, two schools, one independent living agency, one diverse church in a low-income neighborhood, and one African American Cultural Center.
4. Enhanced competitiveness for a specialty crop farmers market serving a least-resourced county area, having increased sales by 118% percent from the start of the project.

Beneficiaries

The beneficiaries of this project include low-income farmers and high-need residents (served by awarded sub-projects) received greater access to fresh produce via strategically located community or onsite gardens, an EBT-enabled and well-promoted farmer's market, and training in growing, preparing, preserving and selling specialty crops. In addition, K-12 students enriched by participation in CCA-supported school gardens and associated instruction, culinary demonstrations and classroom-based specialty crop nutrition lessons.

More than 10 specialty crop growers increased specialty crop sales at a supported farmer's market by 118%. The regional specialty crop industry and local economy received the added benefit of a conservatively estimated 150% multiplied economic effect of increased local specialty crop spending. Over 5,000 people gained access to specialty crops via 10 farm sites on 5.5 acres, including served schools, housing projects, shelters, food deserts, disability/senior/cultural/ centers. More than 400 K-8 students and over 1,600 low-income residents reported increased capacity for nutritional and economic self-reliance in post-event surveys, having gained vocational skills to cultivate/prepare/preserve/purchase/sell an estimated collective $20,000 in specialty crops per year. Subproject participants practicing increased consumption of specialty crops will benefit from improved health outcomes, reduced medical costs, and increased work productivity and quality of life. Three neighborhoods with formerly derelict properties were enlivened as new gathering spaces dedicated to cooperative specialty crop growing/eating/promotion.

Lessons Learned

Project sustainability was an insurmountable issue within some project designs. Future subgrant projects without a clear path to sustainability in the initial design will not be considered for award.

To gauge project results, two surveys were administered prior to June 2015, measuring local cultivation, marketing, purchase, preparation, preservation and consumption activity. The surveys included a previously-piloted Local Specialty Crop Activity Survey (LSCAS). LSCAS was administered to 165 respondents (approximately two-thirds of whom had participated in the project) via the project website and social media pages, at farmers markets, and at food-related events. This survey was designed to: a) measure local specialty crop activity as a function of project participation; b) provide a general informative population baseline for local specialty crop activity; c) measure preferences pertaining to current and potential specialty crop activity. The surveys also included a Longitudinal Survey (LONGS), administered online and in-person to 130 project participants. This survey was designed to measure change within project participants as a function of: a) number of project instructional activities attended; b) attendance at specific kinds of project events. Survey results and conclusions/observations/lessons include the following:

1) Ongoing increased specialty crop consumption and purchasing activity is associated with project participation: Respondents were almost twice as likely to eat more daily servings of specialty crops as a function of project participation. Among project participants, only 26% reported low specialty crop consumption – three servings or less per day – versus 51% for non-participants. The rest of project participants reported consuming considerably more. These findings were supported by the LONGS results: 57% reported eating more specialty crops as a percentage of their diet since attending project events, indicating that the information, cooperative activity and reinforcement of project participation may have a lasting effect on diet choices. Relatedly, 52% of LONGS respondents indicated that they purchase more specialty products from local growers than they had prior project participation, suggesting participation may also have a lasting effect on purchasing choices.
2) For consumption and purchase of specialty crops, convenience is key. This points to a market opportunity for value-added products, and for convenience-focused sales strategies. When respondents were asked in the LSCAS why they do not eat more daily servings of specialty crops, the majority (55.4%) answered "no time to prepare them." Other reasons included "can't afford it" (25.0%); "not easy to buy" (17.9%); "don't know how to cook them" (12.3%). The majority answer "no time to prepare them" and the secondary answer "don't know how to cook them" indicated not only a demand for culinary instruction but an important marketing opportunity for value-added products: e.g., ready-made salads, soups, dried fruit, etc.

3) Ongoing increased specialty crop preparation activity is associated with culinary instruction opportunities. The apparent demand for culinary instruction implied above in the LSCAS response "I would buy more specialty crops if I knew how to cook them" was supported by the reported usefulness of participation in the project's culinary instruction events in the LONGS – 93% of participants indicated habitually preparing/preserving more produce at home after having attended project culinary events. This large increase highlights the potential of culinary and food processing demonstrations in driving changes in specialty crop preparation activity.
4) Ongoing increased specialty crop cultivation activity is associated with farming education opportunities. Participants increased growing of specialty crops after project involvement. Individuals who attended at least one of the project's specialty crop educational events were almost twice as likely grow food on their own and/or in shared gardens, compared to respondents who did not attend any of the project's specialty crop events (30% vs. 16%). The nearly doubled percentage growing specialty crops as a function of project participation (30%) was reflected more modestly in the Longitudinal Survey – among LONGS respondents, 59% reported growing more specialty crops than prior to project involvement. LONGS results also showed a steadily increasing association between the number of project workshops attended and the amount of specialty crops grown afterwards. Among respondents who had attended one event, 34.6% stated that they subsequently grow more specialty crops; among those who had attended two or three events, 55.3%; and, among those who had attended four or more events, 73.3% reported more specialty crop growing than prior to attending project events. Results may indicate the effectiveness of educational farming events in sustaining and building farming activity among those showing initial interest.
5) Increased interest in farming is associated with the opportunity to farm cooperatively. For the LSCAS question: "What would encourage you to grow your own food?" the most common response (58%) was "more time/opportunity to garden with others." Among non-participants, those expressing interest in growing food indicated that desire to garden-with-others was strong (59%). Write-in responses mentioned opportunity to "spend more time with family" and "make new friends" (as part of a gardening experience) would encourage respondents to grow more specialty crops. Lack of gardening equipment and land were included as limiting factors in several write-in responses, and over one-third (34.3%) of respondents stated that "opportunities to learn how" would encourage them to grow their own food. Project community and collaborative gardens offer this social element, as well as learning exchange and opportunities for equipment/land sharing, and time-saving task-sharing.
6) Ongoing increased specialty sales activity is associated with investment and training. Three percent of responses to the LSCAS indicated selling/marketing of self-grown specialty crops – reflecting small farmer numbers in the general population – and 100% of these reported project participation. Ten percent of LONGS responses indicated either increased sale of self-grown specialty crops, or newly selling self-farmed specialty crops after project participation. These results suggest that the project attracted current/interested farmers, and increased respondents' likelihood to farm for sale.
7) Educational and cooperative opportunities can have a lasting effect on communities. Survey results showed that information obtained as a result of project participation was retained and used. Nearly half (49%) of LONGS respondents stated that they "often" use the information gained from project participation, and all but one stated that they make use of skills gained from the project on occasion. These results indicate that projects like this are effective in increasing specialty crop knowledge, skill and activity among participants, and likely also among those influenced by project participants. Survey results further suggest that projects like this are an important factor in building and maintaining more sustainable food systems.

The project team discovered that some target population communities struggle so completely as a result of deep poverty that the most significant accomplishment of some of the sub-projects was to spotlight the areas of community dysfunction, and to begin to identify and design long-term strategies to address these. The project team learned that successful local food systems depend on a significant degree of community functionality. Similar projects should focus on developing bonds of trust and connection within the targeted community.

All of the target outcomes were met or exceeded based on all subgrant outcome measures in aggregate.

Additional Information

Project survey links:
https://www.surveymonkey.com/r/LSCASCultivatingCommunity
https://www.surveymonkey.com/r/CultivatingCommunityLONGS

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 35	**Project Title:** Vine and Branches Community Supported Agriculture	
Grant Recipient: Stanislaus Multi-Cultural Community Health Coalition	**Grant Agreement No.:** SCB12035	**Date Submitted:** December 2015
Recipient Contact: Cleopathia Moore-Bell	**Telephone:** 209-522-6902	**Email:** Cleopathia@westmodestocollaborative.com

Project Summary

The program's purpose is to increase the availability and affordability of specialty crops for consumption to low-income individuals residing, working or attending church in West Modesto, California. A lack of neighborhood stores with fresh affordable specialty crops in close proximity was identified as a barrier to healthy eating. The Community Supported Agriculture (CSA) operated as one "prong" of a larger, multifaceted effort: (1) partnering with local farmers; (2) expansion of farming efforts; (3) establishing a community garden and; (4) expanding the local Farmers' Market (FM). Affordable and accessible specialty crops provided an addition to community education on healthy eating practices.

The project evolved at a crucial point where the West Modesto/King Kennedy Neighborhood Collaborative (WMKKNC) identified important next steps needed to increase availability of specialty crops to West Modesto. It afforded an opportunity to expand existing farming at the Ceres site, and a farm director to oversee the expansion.

The project did not build on a previously funded Specialty Crop Block Grant Project.

Project Approach

The approach to address the Work Plan activities included the following:

Identify and assign responsibilities of the director, program manager and coordinator.
The director responsibilities: hiring/engaging contractors to include the farm director, evaluator, and marketer; working with partners including the city of Modesto to develop a Memorandum of Understanding (MOU) and support for the project respectively; directing the program manager and accountant regarding the financial status of the project, audit requirements and participating in the audit process; working directly with the marketing firm on messaging for the project, and working with staff to develop and submit the required reports including the financial report.

The program manager responsibilities: oversight of the day to day operations, following the grant objectives and deliverables, decision making in hiring support staff, working with the farm director in ordering supplies, monitoring expenditures as related to grant, providing support to the coordinator, including monitoring project specific time sheets for payroll.

The coordinator had direct responsibility for the CSA program and the FM (assigning staff and volunteers, maintaining documentation of all members participating and ensuring calls were made prior to each CSA/

FM), worked with the farm director to train staff and volunteers, and assigned all to the urban garden or farm, maintained hours worked and monitored their reliability and productivity to determine future involvement. The coordinator oversaw the specialty crop produce, visited the farm the week of the CSA to determine availability of specialty crop produce prior to the CSA or FM, and determined the need for additional specialty crop produce from local farmers or designated supplier. The CSA/FM was held the first and third Thursdays of the month. In addition the coordinator maintained records of expenses and revenues for the project, the amount (in weight) of the specialty crop produce provided from the farm/garden, the community gardeners and others.

The project team identified and contracted a skilled person with knowledge of farming, gardening, growing and harvesting specialty crops in California. The East Stanislaus Resource Conservation District (ESRCD) assisted the project at the initial inception, with guidance and oversight of the Ceres urban farm coordinator; but the farmers were not able to provide the oversight needed to guide that part of the project. The owner of a farm was approached and agreed to support the collaborative efforts in enhancing the Ceres farm and implementing the urban community garden.

The expansion of the Ceres urban farm, grew from about .025 acres being cultivated to the majority of the area 2.5 acres being developed in production of specialty crops.

The farmer director has and continues to maintain his operation in Richmond, California. He has a long history of working in third world countries to provide fresh specialty crop produce and teach farming in those countries. He has also worked with UC Santa Cruz students to gain experience in producing specialty crops.

Project staff worked through the process of engaging all ministers involved with City Ministry Network in a discussion of the purpose of the Specialty Crop Block Grant, the need to establish a formal MOU and ultimately obtaining that signed MOU for use of the property.

City Ministry Network contributed access to one acre of land next to the West Modesto King Kennedy Memorial Center (WMKKMC) site for the community garden. The property with unmaintained weeds at the start of the project now contains a one-half acre community garden. Residents/adults and youth participated in the development and cultivation of the community garden.

The project team solicited local farmers as well as community gardeners in providing specialty crops for the CSA and FM (the FM merged into the CSA to provide year round specialty crops rather than have one during the summer (three months only) and restart the CSA). Engaged local farmers to participate in the farmers market: three farmers up to six participated. Farmers attending the local FM were approached along with farmers on the board of the ESRCD. Many of these farmers were willing to provide assistance to staff, but none were able to provide specialty crops, since the majority were dairymen. Local large farmers were more likely to participate in a FM held downtown because those patrons were able to pay the requested charge. Others frequented the FM in the Bay Area. The county supervisor for this area solicited support from a farm co-op to assist. There were a total of six local farmers/producers providing specialty crops with one of them primarily supporting during the fall/winter.

Engaged the Jr. High School instructor and youth in planting and harvesting the community garden during the first year of the project. The high school principal and junior high teacher assisted in engaging ten junior high students in working on the community garden. The principal, teacher and students initially met on a Saturday with the collaborative to clear the land of debris in order to begin the project. After the initial clearing, once a week the students would spend three to four hours working the soil, planting and later harvesting. This worked well since the teacher loved gardening and the principal had given permission for the site to be a training site for the benefit of the students and families. Unfortunately, yet fortunately the Jr. High School was able to acquire a grant through an award granted to Modesto city schools as a result of the school's community involvement and move to provide gardening on each school site. The result of the school's garden is families can receive locally grown fresh specialty crops free of charge. While this reduced those coming to the CSA, the ultimate goal of providing California locally grown specialty crops to low income residents is being supported through the increase of Modesto city schools gardening efforts in seven schools.

Project staff engaged the senior citizens and about ten boys and girls club students in assisting with the community garden, once the school was able to start its school garden. From 20-40 seniors gathered every Wednesday at the Center. These seniors were invited to participate in working, either the local garden or the Ceres farm site as they expressed interest in gardening. Some were members of the CSA, but the number of participants decreased as the seniors could no longer be as active or moved away with family. Six seniors agreed to work the Ceres site. It proved too daunting for many so the number of hours dwindled from four hours to one to two hours once or twice a week.

Project staff conducted outreach and education using both community health workers and promotors to provide door-to-door outreach and engagement throughout the community. Community health workers and promotors take specific areas of the neighborhoods and go door to door eight hours a week conducting outreach. Outreach generally entails walking throughout the community, providing educational and informational material to those met along the way including stores, schools, but more specifically those in their homes. During this time they encountered over 1,800 contacts a year who received information regarding the collaborative services. Of those 1,800, there were approximately 600 who were specifically engaged where they agreed to avail themselves of education and information beyond receiving the flyers (thus outreach and engagement). Along with other service information, these 600 received explanation of services and were provided information regarding the availability of fresh specialty crops through the CSA and FM, and invited to become members. They were engaged in a dialogue which takes more time, and were provided a nutrition guide which could be placed on their refrigerator. This guide was developed in response to resident's request to give them something they could see daily that illustrates the nutrients/vitamins within specific specialty crops, the function of the vitamin.

Project staff developed and implemented a marketing campaign which included distributing flyers educating families about specialty crops and the CSA, and inviting them to participate. Flyers were placed in the local newspaper with distribution throughout the 95351 and 95358 zip codes covering West Modesto, California. Year three marketing of the project was expanded to 95354 and 95350 zip codes which are contiguous to West Modesto based on the consultant's recommendation. It was evident flyers had been received in the newspapers, because calls and memberships increased by at least five and up to 27 participants. This was a boost to the membership. The disbursement of resident families and seniors moving to be with family contributed to a decrease in participants/members, thus the flyers helped offset some of the loss. Efforts to continue marketing will be important to the future of the CSA/FM.

Project staff ensured all items purchased for this project were on the approved list of fruits, vegetables and nuts that qualified as specialty crop items. All orders for seeds/seedlings or trees were compared to the approved list, and the orders remained consistent throughout the project period. Actual purchases from program income generated were also consistent with the approved specialty crop items.

Goals and Outcomes Achieved

Increase the quantity of California Specialty Crops-Produce (i.e. fresh fruits, vegetables and nuts) consumed by 5% to 7% as measured by a random self-reported pre and post surveys.

Activity included increasing acreage of the Ceres Site (Learning Center) for production of specialty crops. Result: almost all of the property was cultivated to growing specialty crops (from 1.5 acres to 4.5 acres). Activity: Develop a Community Garden (Urban Farm) in west Modesto. Result: a one-half acre community garden was developed including raised beds for production of specialty crops.
Activity included increasing the provision of accessible and affordable quality California grown specialty crops, by increasing the number of farmers participating in the current Farmer's Market and piloted Community Supported Agriculture (CSA) program: Result: The participants doubled from 3 to 6 specialty crop farmers.

A Community Supported Agriculture program was initiated to supplement the Farmer's Market which was held from June-September each year of the project. The CSA program had the benefit of being held indoors year round irrespective of inclement weather. The CSA was held from 11 a.m.-2p.m. followed by the Farmers Market, which was held outside in the park from 3 p.m.-7 p.m. A pilot was initiated where the CSA hours were extended during the summer to include Farmers Market services. Thus, residents who wanted to purchase based on the Farmers Market concept could attend anytime and purchase according to their needs/desires. CSA participants could continue to pick up their bags during their designated hours, while also being able to take advantage of the extended hours when needed. The merging of the two (CSA & Farmers Market) activities has been beneficial to staff, participants and farmers who were able to participate in providing specialty crops when possible, without the burden of having their staff on site as required for a certified farmers' market. This was especially welcomed by community gardeners who participated as their ability permitted. Based on a thorough review of eligible and ineligible specialty crops, project staff verified the program only supported production and marketing of eligible specialty crops.

The long term goal is to have the Ceres Site utilized by schools, clubs and residents who want to continue learning and benefitting from the production of specialty crops. An increase of adults (5) and young adults (5) began working and learning production. The Urban Farm with its raised beds has already turned into a place for youth (who live in the community) to work and learn the value of farming. WMKKNC recently partnered with Boys & Girls Club establishing a West Modesto chapter. Youth activities include the Urban Farm site for their Master Gardening Program experience, with up to 20 youth. Ten youth participated.

The actual accomplishments compared with the goals established are as follows:
Increase acreage of Learning Center (Ceres farm) from 1.5 to 4.5 acres. The initial estimation of 1.5 acres being cultivated was actually only 0.25 acres, with the final cultivated acres measuring 2.5 acres, which constituted all of the cultivated area.

Developing a Community Garden in West Modesto. A community garden was developed on ½ acre of land owned by City Ministry Network. Raised beds allow the movement of the garden if City Ministry decides to sell the property.

Engage local farmers to participate in the Farmers Market and Community Supported Agriculture. By the end of this project there were 6 farmers participating in providing specialty crops, with one of the 6 being the WMKKNC Ceres and Community Garden. Contributors included Project UPLIFT, Fresh Point and Harvesting Futures. Two small farmers with community gardens contributed greatly as they began to increase their production of specialty crops.

Develop Community Supported Agriculture (CSA) Food Basket Program. The program income projected was determined based on a business model developed during a training session at Chapel Hill in North Carolina. It was totally academic and based on survey results from residents. The design for the payment structure of the CSA was unrealistic for a low income neighborhood. The results were below the revised projected revenue of $16,992.52. The actual revenue realized for the entire 2 yrs. 9 months totaled $3,167.12.

Increase the quantity of California specialty crop produce consumed by residents of West Modesto who reside in the 95351 zip code by 5% to 7%. Baseline estimates of fruits, nuts and vegetables were developed during March and April 2013. The average consumption of residents was 15.5 cups per week with 6.3 cups per week of fruits, 2.7 cups per week of nuts and 6.5 cups per week of vegetables. Surveys in 2014 (same months) indicated an increase of 34% in fruits, 15% increase in nuts and 41% increase in vegetables. The subsequent follow-up survey in 2015 indicated the baseline was less but nevertheless quite substantial with a total increase of 13% overall-both fruits (18%) and vegetables (21%) were above the baseline while nuts (21%) was below base line.

The Community Garden was created adjacent to the King Kennedy Memorial Center in West Modesto. This property was unmaintained weeds at the beginning of the program. The size of the community garden is one-half acre and included raised beds for growing some of the specialty crops. Residents participated in the development and cultivation of the Community Garden.

One of the major successful outcomes of the project included having a community with one of the lowest incomes and population turnover, 176 families/individuals purchased specialty crops for families with an average of 4 children (range 3-9yrs.) and 2 adults per home making specialty crops available to a total of 880 through the bimonthly CSA.

Beneficiaries

Primary beneficiaries were local small specialty crop farmers providing the 22,000 residents within the 95351 zip code with fresh California specialty crops through farmers markets. Additional beneficiaries were residents from contiguous zip codes who participated in the CSA/Farmers Market because of the quality of the specialty crops and the affordable cost. Towards the end of the project residents from as far away as Turlock, Ceres and Empire, California have signed up to participate in the CSA. This represents about 10-15% of participants from outside the community. This addition provides positive financial support that benefits the specialty crop growers who participate in the CSA/Farmers Market.

Over the period February 2014 - May 2015 there were 25 food demonstrations and hands-on cooking classes given as a part of the project: 19 food demonstrations and 6 cooking classes provided to 181 attendees featuring specialty crops offered through the CSA program.

Including the Community Garden and Urban Farm, there were six small farms/gardens that benefitted from the projects accomplishments. The potential economic impact is good for those who continue to participate. An ongoing tracking system database was developed for participation in the CSA program and provides information on program participation, entry (new participants) and exit (non-participation).

Of the 179 participating in the CSA, each represented an average family of 4 with 1 representing the lowest and 9 representing the largest family size, therefore providing specialty crops to an average of 716 persons.

Lessons Learned

Lessons learned were: (1) Small non-profits desiring to participate in a grant project of this magnitude need to be prepared financially as reimbursements may take up to several weeks; (2) the valley experienced a drought over a four-year period with the last two years greatly impacting the ability to maintain specialty crop produce due to restraints on water use, and necessitated working with the city to establish a well for water (a lengthy process), which would provide water for the urban garden. Even with the well, problems with the drought continued because of major restrictions in using water without incurring fines.

The results of a survey introducing residents to specialty crops and tracking their consumption over time was an unexpected positive.

Another outcome has been the slow but steady increase in people coming to West Modesto to participate in the CSA. Because residents turn over often in this community, having steady participants is crucial to the continuation of the project.

The objective to increase consumption of specialty crops consumed in the community was not what project staff projected. Project staff learned not to base expectations on what more established communities and producers report with their CSA, and to ask more questions when engaging a consultant who has more positive experiences due to a more prosperous and enlightened community.

The major question and answer that eluded project staff was “should the focus be on growing more specialty crops before engaging more residents”, or “do you increase involvement with residents and production of specialty crops simultaneously”.

Additional Information

Figure 1: Consumption of Fruits, Nuts and Vegetables

Vine and Branches Community Support Agriculture
Fruit, Nut and Vegetable Consumption in Cups per Week
Baseline 2013 vs. 2014 and 2015

	Fruits	Nuts	Veggies	Total
Baseline 2013	6.3	2.7	6.5	15.5
March-Apr 2014	8.4	3.1	9.2	20.7
% Change 2014	34%	15%	41%	34%
March-April 2015	7.4	2.1	7.9	17.4
% Change 2015	18%	-21%	21%	13%

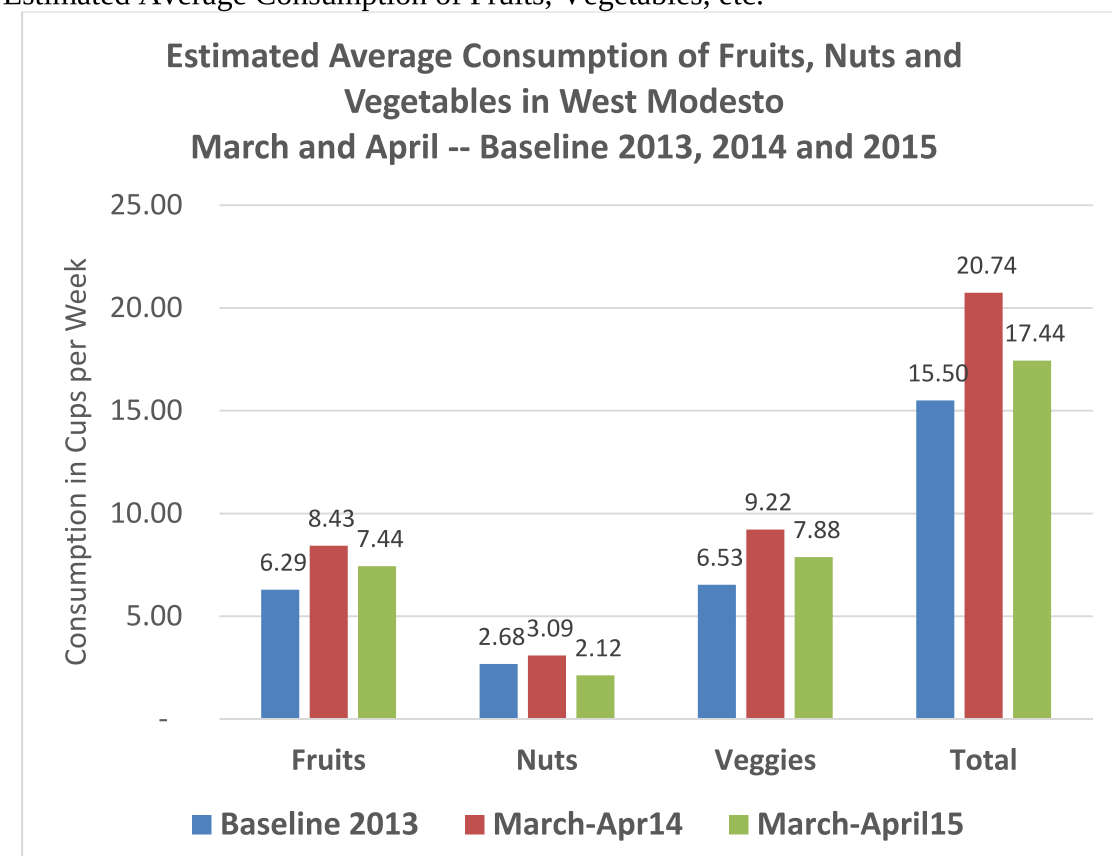
Outcome: Increase the quantity of California Specialty Crop Produce (i.e. fresh fruits, vegetables and nuts) consumed by the 22,000 residents of West Modesto who reside the 95351 zip code; by 5% to 7% as measured by a random self-reported pre (benchmark) and post (target) surveys, mailed to the residents via their utility bill and administered by the evaluator.

Result: Baseline estimates of fruits, nuts and vegetables were developed during March and April of 2013. As shown, the average consumption of residents was 15.5 cups per week with 6.3 cups per week of fruits, 2.7 cups per week of nuts and 6.5 cups per week of vegetables. Follow-up survey data in March and April 2014 indicated a substantial total increase of 34% with 34% increase in fruits, 15% increase in nuts and 41% increase in vegetables. For the subsequent follow-up survey in March and April of 2015 the increase over baseline was less but nevertheless quite substantial with a total increase of 13% overall; both fruits (18%) and vegetables (21%) were above the baseline while nuts (21%) was below baseline.

Figure 2: Community Garden before Project

Figure 3: Community Garden after Project

Figure 4: Estimated Average Consumption of Fruits, Vegetables, etc.



CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 36	**Project Title:** Infrared Heating for the Improved Drying Efficiency and Quality of Almonds and Pistachios	
Grant Recipient: United States Department of Agriculture, Agricultural Research Services	**Grant Agreement No.:** SCB12036	**Date Submitted:** December 2015
Recipient Contact: Dr. Zhongli Pan	**Telephone:** 530-979-0332	**Email:** zhongli.pan@ars.usda.gov

Project Summary

California produces about a million tons of almonds and pistachios annually and is ranked the top commercial producer of tree nuts in the United States. However, for each commodity about 3% production losses are resulted from adverse weather conditions followed by improper drying practices. For almonds, the Almond Board of California has expressed an urgent need to develop a quick drying method to remove moisture caused by rain during harvest season to reduce quality deterioration and improve product safety. Exposure of almonds to wet conditions results in concealed damage, discoloration and unpalatable off-flavor. For pistachios, industrial sorting in water bath before air drying results in significant moisture gain on the nut surface. Therefore, quick drying of pistachios is vital to avoid shell staining, decay and microbial contamination. The current hot air drying practices have low energy efficiency and drying rates, high labor and energy efficiency and do not guarantee safe products. Previous studies revealed that improved drying rate and product quality can be achieved by using infrared (IR) heating product to a temperature of 60-70ºC for 1-2 minutes for rough rice and walnuts followed by natural cooling. In addition, IR pre-heating followed by tempering can pasteurize almonds with over 5.0 log reductions of *Salmonella*. The current reported study was performed to reduce the drying time and improve the safety of almonds and pistachios using sequential IR and hot air (SIRHA) drying method and to study the effect of SIRHA drying treatments on the quality of nuts and decontamination of *Enterococcus faecium*.

In 2010, California produced approximately 1650 and 522 million pounds of almonds and pistachios, respectively. Potentially, $113 million of revenue loss could be saved when 3% loses of each commodity are prevented by quick and efficient drying. In addition contamination by *Salmonella* and related recalls present health hazards and great economic losses to the almond and pistachio industries. For instance, in 2009, the Food and Drug Administration recalled over 16 million pounds of pistachio and pistachio-containing products implicated with *Salmonella* contamination. Developing an IR based drying technology will prevent the commodity loss, save drying time and energy and also improve the safety of nuts against disease causing pathogens.

The project did not build on a previously funded Specialty Crop Block Grant Project.

Project Approach

Pistachio and almond samples collection

Almond samples were collected from a soil lab in Colusa County, California during October 2012. Late harvest variety, Monterery almond trees were shaken to the ground and the almonds were simulated for rainy conditions by spraying water. The almonds were collected a week after spraying with water. The wet almonds were stored in the freezer at -30°C until it was used for drying.

Pistachio samples were collected from a pistachio processing plant located at Kettleman City, California. The popular Kerman variety pistachios were collected immediately after hulling and water sorting in wet condition. The pistachios were stored in the freezer at -30° C until it was used for drying. The pistachios and almonds were thawed at room temperature to bring them to the ambient temperature before drying.

SIRHA Dryer

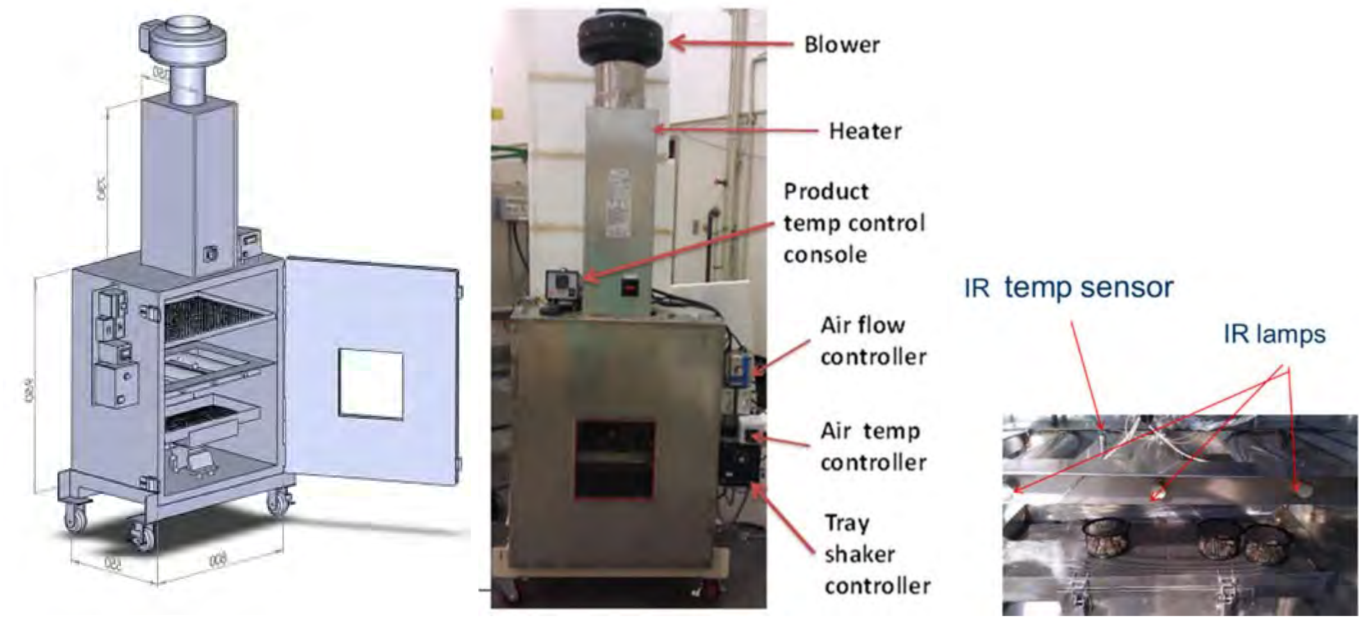


Figure 1. Schematic (left), photo (center) and inside (right) views of sequential IR and hot air (SIRHA) dryer.

The SIRHA dryer developed for drying and decontamination studies of almonds and pistachios is shown in figure 1. It has a blower at the top which draws air from the room at the ambient temperature and passes through a heater. The air flow rate can be changed using the air flow controller. Air flow was set at 2 cubic meter per minute during the experiment. The electric heater placed below the blower is used to heat the air from the blower. The temperature of the heated air is maintained at the required temperature (60-70ºC) using the controller. The IR heater panel has three quartz IR emitters placed at 30 cm apart and their intensities are controlled by a temperature control console. The temperature control console controls the intensity to achieve a required product temperature depending on the product temperature measured by IR temperature sensor and fed to the console. The material to be dried is placed on the vibrating perforated metallic tray. Electrical controls are provided to operate the dryer in IR heating mode or hot air mode or in combination mode of both.

For drying treatment, a single layer of 20 pistachios were spread in a 8.5 cm diameter circular cup holder and placed in vibrating tray and were vibrated to tremble them for uniform exposure to IR heating. Similarly, a single layer of 15 almonds were spread into 13 cm diameter cup holder and trembled for almond drying. Triplicate samples were dried for each experiment and average values are reported.

1. Drying and decontamination of pistachios

a. Temperature selection for IR drying of pistachios

The objective of this experiment/activity is to find an optimum temperature of heating for drying pistachios without affecting the quality of pistachio kernels. For the experiments pistachios were dried with IR heating mode at product temperatures of 60º, 65 ºC and 70 ºC until pistachios were dried to <9% moisture. In order to compare the IR drying with hot air drying, pistachio samples were dried in hot air mode at an air temperature of 70 ºC. The initial moisture content of almonds and pistachios were determined by drying 10g of samples at 105 ºC for 24 h in a hot air oven. The moisture contents were calculated from the moisture loss. The final moisture content after the drying treatments were determined from the initial moisture content and the moisture lost in the drying process.

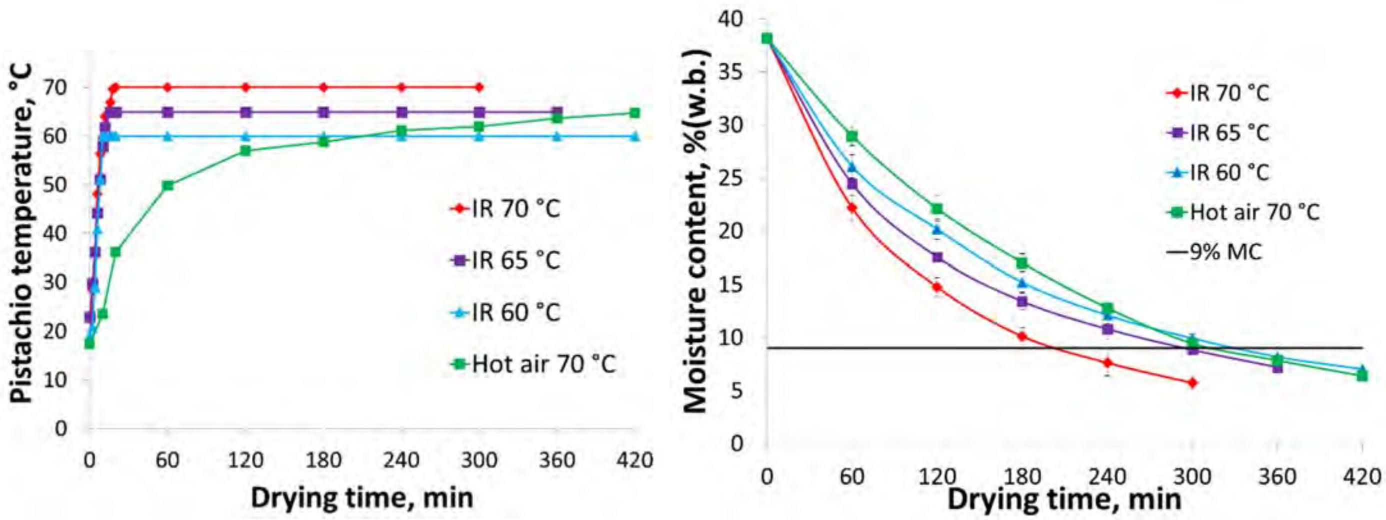


Fig 2. Pistachio temperatures (left) and drying curves (right) at different IR temperature treatments

The temperature profiles of pistachio samples during IR heating and hot air drying are shown in figure 2a. It is seen that the IR heating treatments increased the temperature of pistachios to the drying temperature in 25 seconds and maintained the temperature of pistachios for the rest of drying. The hot air drying gradually increased the temperature of pistachios from the ambient temperature to about 65ºC in 7h. The loss of moisture from the pistachios during the drying period is depicted in figure 2b. The IR heating caused a quick reduction in the moisture during the initial one hour of drying. This might be due to the faster rate of increase of the temperature of the pistachios compared to hot air drying which increased the temperature of pistachios to lower than 50 ºC as shown in figure 2a. The time taken by the IR drying at 70°C to reduce the moisture content of pistachios from 38.15% (wet basis) to 9% moisture level was 200 min while the time taken by hot air drying was 305 min. This shows that the IR drying at 70°C could save 105 min or 34.4% of drying time.

To determine the quality of pistachios dried by IR heating and hot air drying, pistachio samples dried by various drying conditions were inspected for physical quality parameters and the chemical quality of oil. The physical quality parameters observed during the inspection included color of the shells, number of pistachios with un-split shells and pistachios with kernels removed from shells. No difference was observed in shell color for all the drying conditions. The total number of pistachios with un-split shells and kernels removed from the shells were less than 3% for all the four drying conditions. To study the chemical quality of pistachio oil, the oil from the pistachio kernels was extracted using the hexane as solvent and then the peroxide value (PV) and free fatty acids (FFA) content were determined using standard methods. The FFA and PV values are reported in table 1. The analysis of mean values showed that the FFA values have no significant difference among all four drying treatments. Whereas the PV values of IR drying treatments are significantly different from the hot air drying. The PV values for three IR drying temperatures did not have significant variation among them.

Table 1. Free fatty acid (FFA) content and peroxide value of IR and hot dried pistachios

Treatment	FFA(%)	P V(Meq/kg)
IR 70 °C	0.71±0.35	1.87±0.53
IR 65 °C	0.68±0.23	1.36±0.31
IR 60 °C	0.46±0.31	1.32±0.13
Hot air 70 °C	0.35±0.29	0.81±0.25

The FFA and PV values were higher for the IR drying than hot air drying and the both of them increased with increase in IR temperature. This might be due to the continuous exposure of the nuts at high temperature for longer time compared to hot air drying. However, the FFA and PV values are within an acceptable limit. Therefore, IR temperature of 70°C was used in further studies. To minimize the effect of the drying on oil quality, IR heating time was kept to less than 2h.

b. SIRHA drying of pistachios

Several sequential IR heating and hot air drying experiments were performed to determine a suitable drying time combination which can shorten the drying time of pistachios without affecting the product quality. For all treatments, IR drying was done by maintaining the temperature of pistachios at 70 ºC (IR-70 ºC) and hot air temperature drying was performed using hot air at 70 ºC. The temperatures of pistachios during SIRHA drying experiment is shown in figure 3a. The temperature of the pistachios rose to the IR heating temperature of 70 ºC quickly (within 25s) and was maintained at 70 ºC for the entire IR heating period (1h or 2h). As soon as the hot air heating mode was started, the temperature of pistachios dropped from 70ºC to 58ºC and 63ºC for experiments after 1h and 2h of IR heating and IR was turned off, respectively. The figure 3b shows the moisture content of pistachios during drying. The SIRHA drying with 2h of IR followed by hot air drying took 265 min to reduce the moisture content to less than 9% moisture content with reduced drying by 40 min or 13.1% as compared to hot air drying. Whereas the SIRHA drying with 1h of IR heating followed by hot air drying took as much time as hot air drying. Therefore, a minimum of 2h of IR drying is required to shorten the drying time by SIRHA drying method.

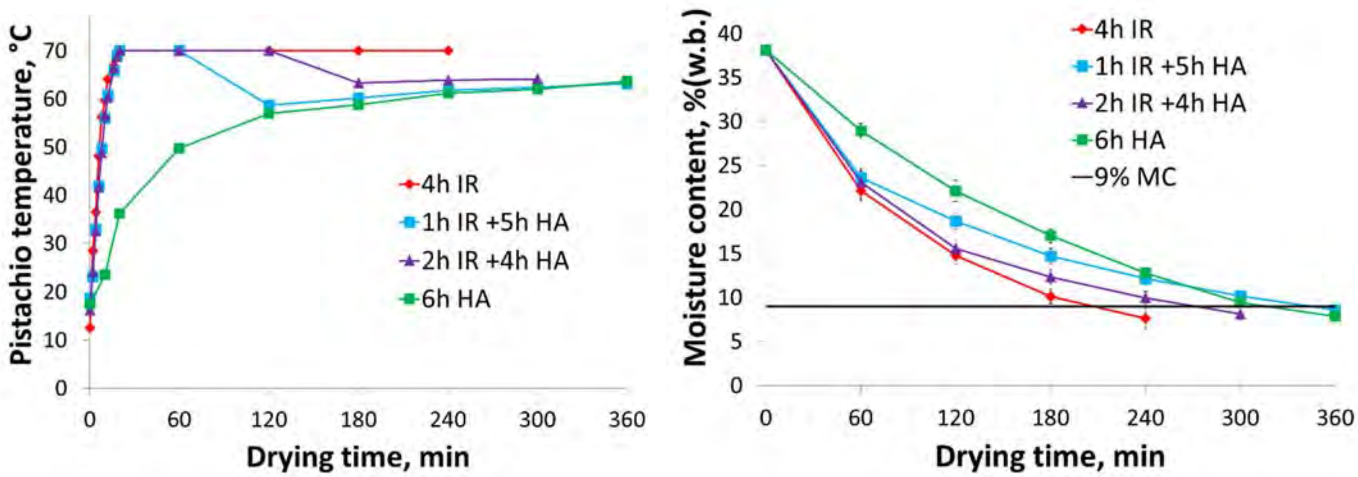


Figure 3. Pistachio temperatures (left) and drying curves (right) during SIRHA drying

c. Decontamination effect of SIRHA drying treatments

To determine the effect of SIRHA drying treatments of pistachios on the inactivation or decontamination of *Salmonella*, pistachio samples were inoculated with *Enterococcus faecium* as surrogate accepted for microbial quality testing by Almond Board of California. A common strain of *Enterococcus faecium* was grown in petri dishes for 2 days at 27°C and added to the pistachios. The inoculated pistachios were allowed to dry for 24h at 27ºC and stored at 10ºC until used by drying treatments. The inoculum levels of *Enterococcus faecium* was determined by separating the pistachios into shells and kernels. *Enterococcus faecium* cells recovered from shell and kernels in 10mM phosphate buffer in a Pulsifier were dilution plated onto tryptic soy agar (TSA) medium. *Enterococcus faecium* colony forming units (CFU) were counted after incubation at 27ºC for 2 days. The initial population of *Enterococcus faecium* in pistachio shells and kernels were determined as 5.47 x10^7 colony forming unit (CFU) per g and 2 x 10^7 CFU/g, respectively.

The inoculated pistachios were dried in the SIRHA dryer and the effect of killing of treatments were determined by separating the dried pistachios into shells and kernels to recover *Enterococcus faecium* cells from shell and kernels in 10mM phosphate buffer in a Pulsifier and plating in TSA medium. The effect of different drying treatments on the decontamination *Enterococcus faecium* is shown in figure 4. SIRHA drying treatments had less than 4 log reduction of *Enterococcus faecium* in shells and kernels. The IR drying for 4h had over 4 log reductions for kernels and about 3 log reductions in shells. Therefore, to improve the decontamination effect to 4 log reduction (practiced by almond industry in California), more drying experiments with tempering periods of 1h or 2h after IR drying of 1h and 2h and before hot air drying were performed.

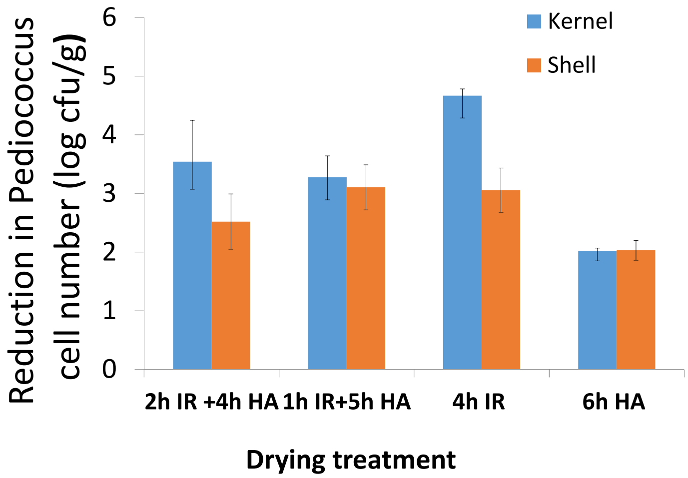


Figure 4. Effect of SIRHA drying on decontamination of *Enterococcus faecium*

d. SIRHA drying of pistachios with tempering

Tempering treatments were done after IR heating by holding the heated pistachios in an air tight container in hot air oven maintained at 70 ºC for 1h and 2h, respectively. After tempering period, the pistachio samples were further dried to a moisture content of less than 9% by using hot air at 70 ºC.

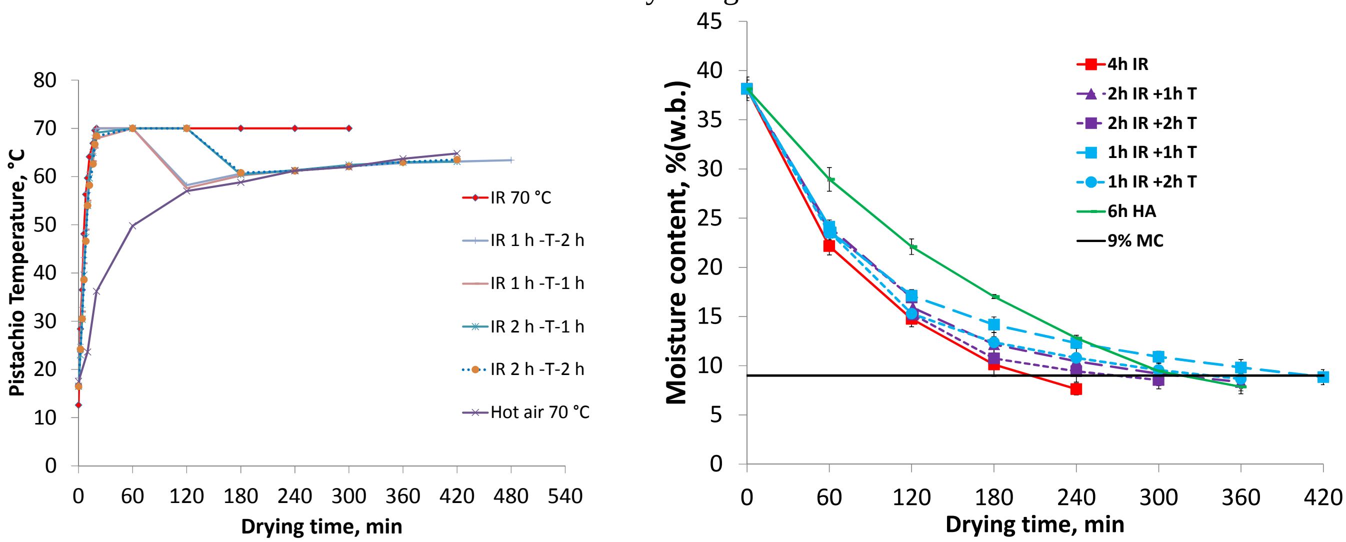


Figure 5. Pistachio temperatures (left) and drying curves (right) during SIRHA drying with tempering (tempering time is not included in drying time in X axis)

The temperature of pistachios during the SIRHA drying with tempering had the same pattern as that of SIRHA drying without tempering. Similarly, the moisture content of pistachios dropped at the same pattern as that of SIRHA drying. However, the total needed time for the SIRHA drying with tempering treatment was extended by the tempering period. This time was not considered in total drying time as the energy involved in tempering is negligible by using an insulated and air tight tempering bins. The drying time for the SIRHA drying with 2h IR +2h T followed by hot air drying is 265 min which is a saving of 40 min or 13.1% compared to the drying with hot air.

e. Decontamination effect of SIRHA drying of pistachios with tempering treatments

The decontamination effect of SIRHA drying with tempering is shown in figure 6 along with that of IR drying and hot air drying treatments. The SIRHA drying treatments with tempering resulted in *Enterococcus faecium* cell reduction of 5.6 log CFU/g in kernels and 5.3 log CFU/g in shells (figure 6). This shows that the drying of pistachios using SIRHA drying method with tempering can be used to produce pistachios very safe against *Salmonella*.

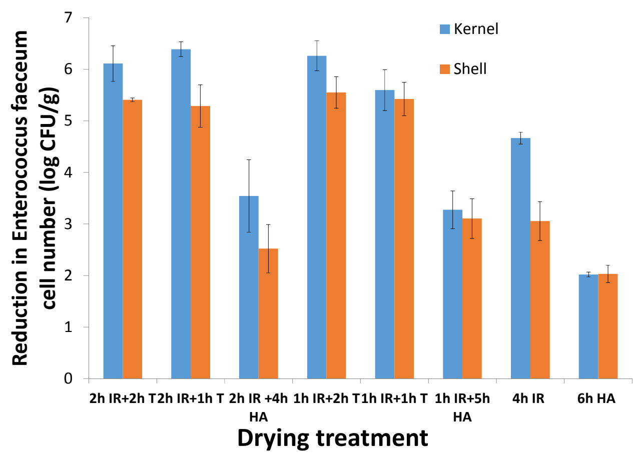


Figure 6. Effect of SIRHA drying with tempering treatment on decontamination of *Enterococcus faecium*

f. Quality of SIRHA dried pistachio samples

The oil samples extracted from the SIRHA dried pistachios were analyzed for the peroxide value (PV) and free fatty acids (FFA) content and the values are reported in figure 7. The FFA values of the SIRHA dried samples with tempering treatment were higher than that from the hot air dried samples and the values increased with the increase in both IR heating and tempering periods. The PV of the oil samples of SIRHA dried pistachios were higher than hot air dried samples and increased with the increase in both IR heating and tempering periods. Though the FFA and PV values are not above the recommended limit for edible oils, the values may rise during treatments which need to be monitored.

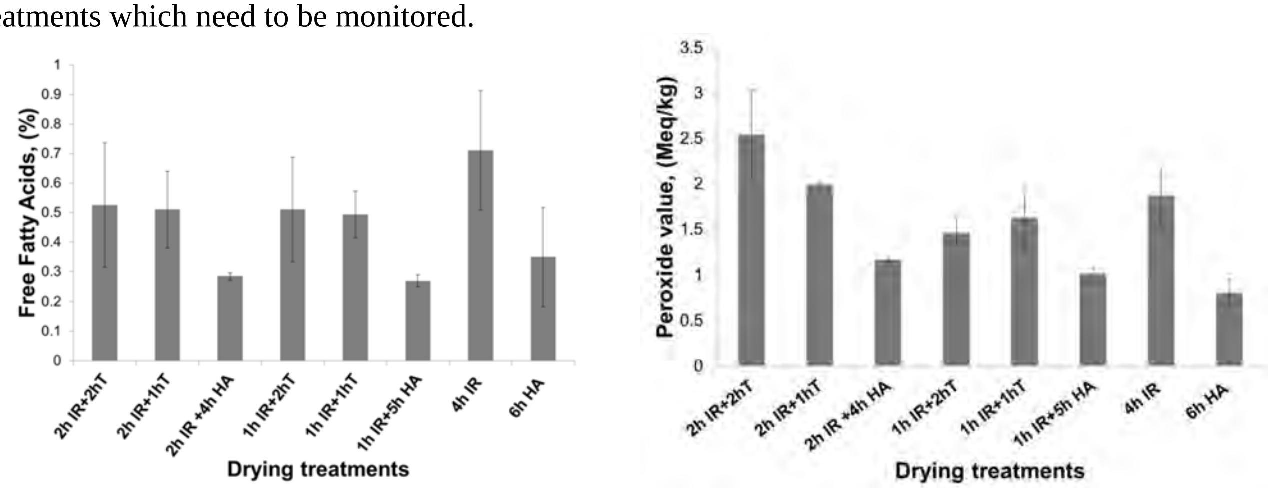


Figure 7. Free fatty acids content (left) and peroxide value (right) of pistachio oil samples dried using SIRHA dryer with tempering treatments

2. Drying of almonds

a. SIRHA drying of almonds with tempering treatments

Decontamination effect SIRHA drying is increased by adding tempering treatments as shown from the drying experiments of pistachios. Therefore, almond samples were dried with SIRHA drier with tempering and the results were compared with hot air dried and IR dried samples. All the drying treatments were performed for a period of 5h which excludes the tempering time.

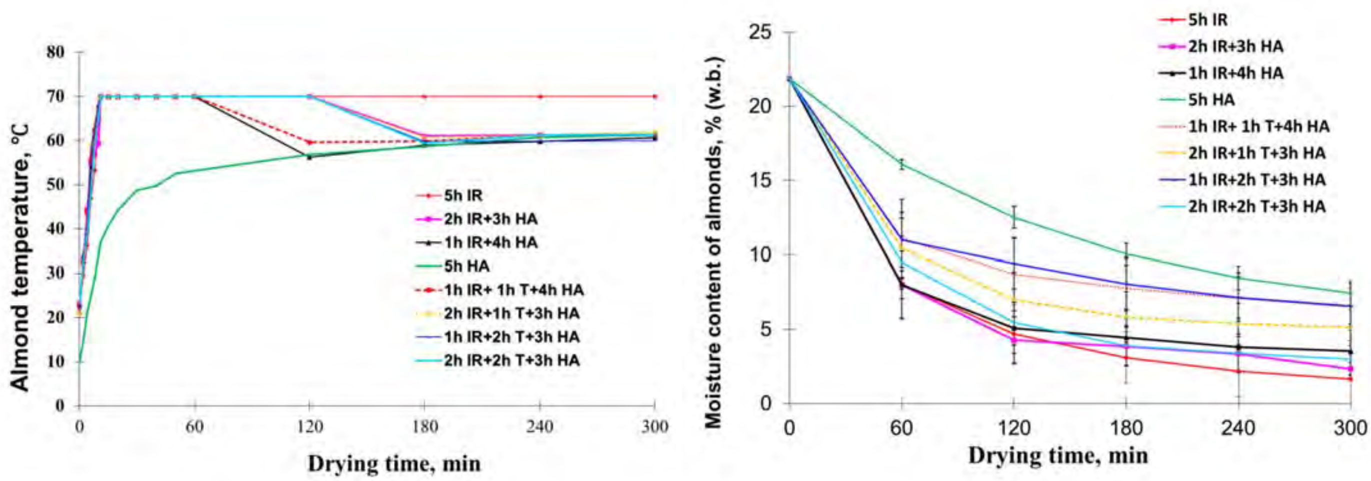


Fig 8. Almond temperatures (left) and drying curves (right) during SIRHA drying with tempering (tempering time is not included in drying time in X axis)

The temperature and moisture content of almonds during SIRHA drying treatments are shown in figure 8. The IR drying had a dramatic reduction the moisture content of almonds due to the quick rise of the product temperature during IR heating causing faster removal of moisture. The moisture levels of SIRHA dried samples with 2h of IR drying were less than 7%, which was the accepted moisture content in almond kernels for hulling. Therefore, SIRHA drying with at least 2h of IR heating followed by tempering and hot air drying is suggested to dry almonds to a moisture content accepted for hulling.

b. Decontamination effect of SIRHA drying of almonds with tempering

The inoculation of almonds was done by following the same procedure used for pistachio inoculation with *Enterococcus faecium*. The dried samples were separated into hulls, shells and kernels carefully to avoid the cross-contamination of microbial cells. The *Enterococcus faecium* cells from the hulls, shells and kernels were extracted separately and plated in TSA plates. The concentration of *Enterococcus faecium* in the hulls, shells and kernels were $1.78 \pm 0.23 \times 10^9$, $2.17 \pm 0.13 \times 10^8$ and $6.4 \pm 0.19 \times 10^4$, respectively. As the hulls were the outer layer, they received more cells during inoculation followed by shells. The cells of *Enterococcus faecium* had to move through the hull and shell layers to reach the kernels which had less concentration in kernels.

The decontamination effect of SIRHA drying treatments with two hours of tempering is shown in figure 9 along with that of hot air drying treatment. The SIRHA drying treatments produced highest decontamination effect on hulls, followed by shells and least effect on the kernels. This might be due to the exposure of surface layer of hulls directly to the high temperature. The kernels which are the inner most layer had less effect by heating and also there were less number of cells in the beginning of treatments which might be also a reason for low decontamination effect.

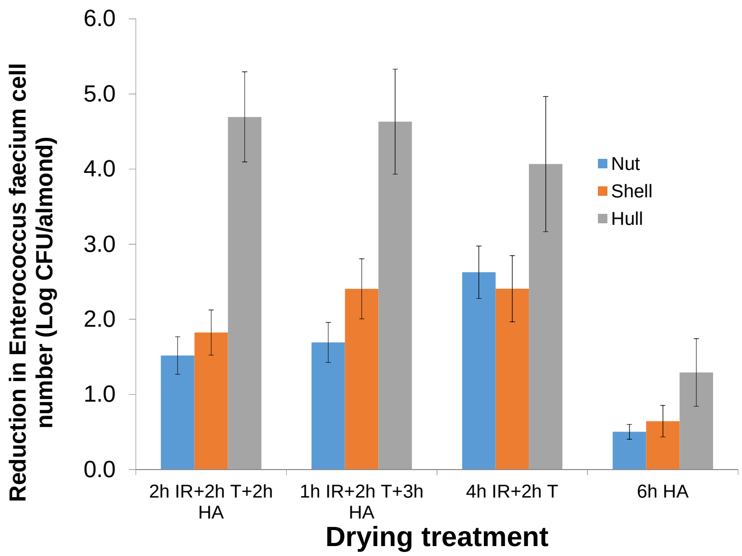


Figure 9. Effect of SIRHA drying with tempering treatment of almonds on decontamination of *Enterococcus faecium*

c. Quality of SIRHA dried almond samples

As the edible portion of almonds is the kernels, which are covered by shell and hull, no visual quality observation was done on the dried almond samples. The almond kernel color did not show any difference among the SIRHA drying and hot air drying. The almond oil was extracted from the kernel and PV and FFA values were determined to assess the quality of almonds.

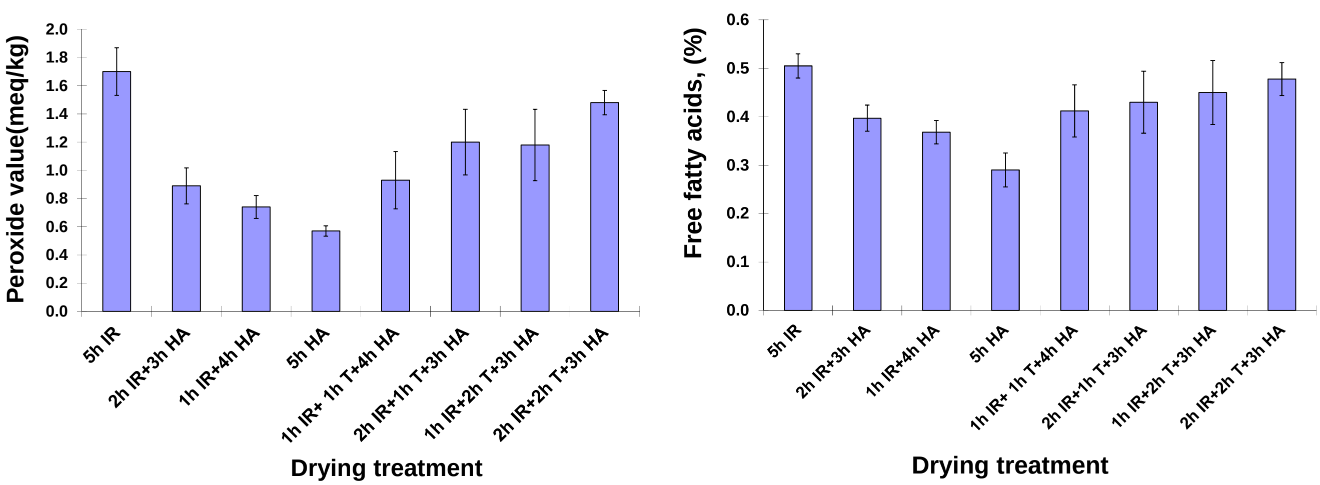


Figure 10. Free fatty acids content (left) and peroxide value (right) of almond oil samples dried using SIRHA dryer with tempering

The PV and FFA values of almond oil samples are reported in figure 10. The FFA values of the SIRHA dried almond samples with tempering treatments were higher than the hot air dried samples and the values increased with the increase in both IR heating and tempering periods. Similarly, PV of the oil samples of SIRHA dried almonds were higher than hot air dried samples and increased with the increase in both IR heating and tempering periods. The PV and FFA values of almond oils were lower than the pistachio oils because the hull and shell layers covering the almond kernels act as protection against heat preventing oxidation of oil.

The Principal Investigators (PIs) and Co-PIs administered the project, supervised and communicated the research progress and findings. They also provided technical and supervisory support to the research team to conduct proposed research experiments. The postdoctoral scholar and graduate students conducted all the experiments for this project. They also analyzed experimental data and drafted progress and final reports.

Goals and Outcomes Achieved

The proposed goal and objectives were achieved by performing the activities reported in the previous section. The drying method based on the SIRHA drying has been developed for almonds and pistachios by identifying the optimum temperature and time for IR heating, tempering time and hot air drying temperature and time. The quality of almonds and pistachios were evaluated from the physical and chemical quality parameters. SIRHA drying with at least 2h of IR drying followed by 2h tempering and hot air drying is recommended for drying almonds to a moisture content of 7% or less which is acceptable for hulling and also had 4.5 log CFU reduction of *Enterococcus faecium* cells on the almond hulls. SIRHA drying of pistachios with 2h IR plus 2h tempering followed by hot air drying provided a saving of drying time by 40 min (13.1%) compared to drying with hot air. Drying with IR alone could save 105 min (34.4%) of drying time for pistachios when compared to hot air drying. The SIRHA method provides additional advantage of *Enterococcus faecium* cell reduction of 5.6 log CFU/g in kernels and 5.3 log CFU/g in shells of pistachios. The chemical quality of almond and pistachio oils from the SIRHA dried samples were less than limit for edible oils. Technology transfer to almond and pistachio industry was conducted through direct cooperation, conference presentations and abstract publications. The research team from UC Davis and USDA had direct cooperation with the almond and pistachios growers/processing industries to collect the samples required for this research. During their meeting the researchers explain objectives of research and the method and also share the results with them. Conference presentations are held at the annual meeting of Institute of Food Technologists (IFT) meeting held between July 14-17, Chicago, IL., and at the Annual Meeting of International Association for Food Protection (IAFP) held between July 25-28, Portland, OR.

The attendees of IFT and IAFP included almond and pistachio growers, nut industry people, and dryer manufactures. Professionals from food science, food engineering, food microbiology, food safety and extension departments of private industries and Universities also attended the meetings. The results of this project, IR drying of nuts reduces the drying time and produces safe products, was explained to attendees. These professionals will be playing a key role in disseminating the projects results by explaining the benefits of IR drying to the other almond and pistachio growers and the nut industry. The benefits of producing safe nuts will improve the marketability of California produced almonds and pistachios in domestic and international markets. Therefore, the presentations at annual meetings of IFT and IAFP resulted in results of the project reaching a broader group of audience involved in the development of nut industry, in addition to the growers and processors. Total attendees were about 3,200.

The long term outcome of this project is to adopt the developed SIRHA drying technology for almonds and pistachios. The project results have shown that time of drying can be reduced for pistachios and the wet almonds can be dried without quality loss using SIRHA drying method. It also produces nuts with improved safety against food borne pathogens. The reduction in drying time will save energy and labor required for processing.

The project has popularized and created awareness on the SIRHA drying method to almond and pistachio industries and general public. It is expected that the project results could help in adopting the SIRHA technology in nut processing.

SIRHA drying method has been developed for almonds and pistachios by identifying the optimum temperature and time for IR heating, tempering time and hot air drying temperature and time. The saving in drying time has been quantified. The quality of almonds and pistachios dried by SIRHA method was evaluated and verified. The effect of SIRHA drying treatments on food borne pathogen (*Salmonella*) has been studied by inoculating *Enterococcus faecium* on pistachio and almond samples. The outcome from this project will directly impact the nut processing industries and growers by increasing the profits to the processors and net income to growers.

The major successful outcome of the project was the development of the SIRHA drying method based on IR heating technology for almonds and pistachios. SIRHA drying with at least 2h of IR drying followed by 2h tempering and finishing with hot air drying is recommended for drying almonds to a moisture content accepted by almond hulling. Drying almonds with IR heating was found to save 105 min (34.4%) of drying time compared to hot air drying. SIRHA drying of pistachios with 2h IR plus 2h tempering followed by hot air drying provided a drying time reduction by 40 min (13.1%) compared to drying with hot air and ensured more than 5 log reduction of *Enterococcus faecium*. Increased safety of SIRHA dried nuts against *Salmonella* has been verified by inoculating *Enterococcus faecium* on pistachio and almond samples and studying the killing effect.

Beneficiaries

The almond and pistachio growers, hulling and processing industries are the beneficiaries of the project. The overall potential benefit will make the California nut industry more competitive in the global market by reducing the drying time and improving the profit and food safety.

California produces over 2 billion pounds of almonds and pistachios combined that include about six thousand growers. Use of SIRHA drying will prevent product losses due to adverse weather conditions followed by improper drying practices that are estimated to be over $100 million. In addition the increased safety of the process against Salmonella can improve the profit by reducing the cost involved in the pasteurization of nuts such as pistachios and almonds.

Lessons Learned

This is a laboratory study and used low quantity samples were used during the experiments compared to the capacity in the industry. A study with large capacity is needed in the future.

The quantification of energy involved in SIRHA drying and hot air drying can not reflect the true energy efficiency due to the small scale equipment. The true energy efficiency should be studied with large scale equipment.

Additional Information

Presentations at International Conferences

Venkitasamy, C., Brandl, M., Wang, B., Zhu, C.,El-Mashad, H., McHugh, T.H., Pan, Z. 2015. Drying and Decontamination of Pistachios by Sequential Infrared and Hot Air Drying. Poster presented at the Institute of Food Technologists (IFT) meeting held between July 14-17, 2015 Chicago, IL. IFT, is an international, non-profit scientific society of professionals engaged in food science, food technology, and related areas in academia, government and industry. It has over 17,000 members who are researchers, food processers and marketing professionals. Total attendees of IFT 2015 were about 7,000. (Attachment 1)

Venkitasamy, C., Brandl, M., Wang, B., Zhu, C.,El-Mashad, H., McHugh, T.H., Pan, Z. 2015. Drying and Decontamination of Pistachios by Sequential Infrared and Hot Air Drying. Poster presentated at the Annual Meeting of International Association for Food Protection (IAFP) held between July 25-28, 2015 Portland, OR. The target audience included food scientists, food technologists, food safety professionals and food microbiologists from several countries. Total attendeeds were about 3,200. (Attachment 2)

USDA Project No.: 37	Project Title: Dust Control in Almond Production	
Grant Recipient: Almond Board of California	**Grant Agreement No.:** SCB12037	**Grant Recipient:** Almond Board of California
Recipient Contact: Gabriele Ludwig/Debye Hunter	**Telephone:** (209) 343-3230	**Email:** dhunter@almondboard.com

Project Summary

Dust emissions from almond production contribute to PM10 air pollution in the San Joaquin Valley (SJV). This project investigated the potential of using a liquid magnesium (Mg) chloride (MgCl) product (MgCl, Dust-Off™) to control dust in orchards. MgCl is a proven dust suppressant and regionally available. While MgCl is a salt, it includes essential plant nutrients and is considered safer than suppressants made from polymers and petroleum products. Determining where the effective rate of dust suppression and agronomic benefit and safety converge is integral in developing dust suppressant applicability in agriculture. The objectives of this project encompass efficacy and environmental safety and include: 1) determining the behavior of soil-applied MgCl in soil and water of orchards with various soil types, climatic regimes and disturbance regimes; 2) establishing performance criteria and effective rates for tree crop applications.

Research on dust emissions in almond orchards has largely focused on mechanical modifications to harvest machinery and practices to reduce dust emissions. However, even while implementing these improvements, the SJV Air Pollution Control District reduced PM10 to narrowly meet federal standards and is still not in compliance with state PM10 standards. Through Conservation Management Plans (CMP), almond growers commit to using a menu of practices to control dust. Many CMP practices are already in use but collectively are insufficient to achieve air quality standard compliance. The CMP practices do not include any dust control products which are proven in other industrial and agricultural applications. The main goal of this project is to add an effective, safe and practical dust control product to the CMP menu of choices for almond growers. This would reduce almond production's contribution to PM10 and reduce potential for even greater regulation that threatens almond production in the SJV.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

1) The Literature Review served to gather information and guide experimental design of the field trials. Information reviewed included pertinent environmental quality regulations; a review of dust control published studies with MgCl and other dust control products; and background information on the behavior of Mg and Cl in relevant environments. Typical dust concentrations in various particulate ranges (total, PM2.5, PM10) found in California almond orchard studies were also reviewed to compare with field results from the current study. Chloride and magnesium thresholds in almond leaf tissue were reviewed. Responses of almond rootstocks to salinity and Cl were reviewed.

2) The Regulatory Review included interviews with staff from air quality control state agencies and vendors of various dust emissions monitoring equipment to determine the best equipment for the field studies. During this phase, it was determined that laser photometer type monitors would be best suited for this type of study; therefore, the original approach to use Portable In-Situ Wind Erosion Laboratory (PiSWERL) technology was modified to include the former technology.

3) The Experimental and Statistical Design/Sampling and Analysis Plan included site selection, treatment design, and monitoring planning. Three cooperators were identified in the Sacramento Valley and the San Joaquin Valley. These three sites (Orland, Waterford, and Porterville) represented a diversity of soil types, irrigation methods, management practices, climate regimes, and harvesting equipment. Treatment design was developed collaboratively between UC Davis, who was consulted on experimental design for dust studies; Cargill personnel, who were consulted for recommendations on treatment rates; and Land IQ, who used the information acquired in Tasks 1 and 2 to determine the best monitoring technology and plan. This task resulted in the development of a study plan that included 4 treatments (including a control with no product applied) replicated 3 times in a randomized complete block design at each of the three study sites. The results from the dust monitoring study were planned for statistical analysis using analysis of variance (ANOVA) for the purpose of determining significant differences between treated and non-treated areas, as well as significant differences between treatments, if any.

4) During Field Trial Implementation, growers were contacted for preliminary data collection (almond varieties on site, irrigation practices, management practices, harvester type, etc.). Specific study sites (within the cooperators' fields) and plot locations (within the study sites) were selected and marked off. Background soil samples were collected in June 2013. Product delivery and an agricultural applicator were coordinated to apply Dust-Off™ after irrigations were ceased but harvest had not yet begun. Product was applied in July 2013 for Year 1 monitoring, and product was applied in July 2014 for Year 2 monitoring.

5) Field Trial Monitoring was conducted during various months throughout the project. Soil salinity and salinity related constituents were monitored five times throughout the study – before the study began to collect background soil salinity levels, after harvest the first year, immediately before the 2nd season application, after harvest the second year, and at the end of the study. At the end of the study, leaf tissue samples were collected and analyzed for Cl and Mg content. Shake, sweep, and pick-up harvest operations were monitored for dust emissions during harvest of the first field season. During harvest of the 2nd field season, only sweep and pick-up operations were monitored because very little emissions during the shake operation in Year 1 originated from the soil; most originated from the tree canopies. Overall, the field study operations were successfully completed. One site (Porterville) did not receive product application prior to the Year 2 harvest season because of residual product constituents found (namely Cl) during the pre-season soil sampling event. Product was not applied to ensure that no damage to the orchard would occur from salinity or specific ion toxicity. During the 2nd year of the field study, one of the study sites (Waterford) was not monitored for dust during the pick-up harvest operation because of a lack of communication between the grower and the harvesting crew.

6) Data Compilation, Analysis, and Interpretation included data analysis, determining applications appropriate for various sites, identification of further research needs, and recommendations developed during the non-growing seasons of the funded years. Both soil salinity and dust emissions data were analyzed for trends. Statistical analysis was performed on the dust emissions data. Statistical analysis was not performed on the soil salinity data because soil salinity was reduced to nil or near nil by the end of the project. Soil salinity data included electrical conductivity (EC), which is a measure of salinity, and chloride (Cl) concentrations. Cl is a component of Dust-Off, (though it dissociates from Mg when the product is applied) and is a potential safety concern for crops because it can have detrimental effects on plant growth at high concentrations. Leaf tissue analysis results were compared to agronomic thresholds for Cl and Mg in almond leaves. In summary:

- Soil salinity (Figures 1 and 2) – As expected, soil salinity was higher in plots treated with a higher rate of Dust-Off. Also expected, soil salinity decreased quicker at sites where there was more rainfall, because rain leached the MgCl below the sampled zone. Final soil salinity sampling showed that salinity and Cl increased at the end of the study, though this increase was minimal. The soil salinity threshold for almonds is 1.5 dS/m. The Orland site soil was higher in salinity at the end of the project in the top foot of soil (in all plots including the control); however, salinity was still below the EC threshold in all treatment plots. At the Waterford site, soil salinity was lower at the end of the project compared to background sampling, which was over the 1.5 dS/m threshold. The Porterville soil data showed that salinity was higher at the end of the project in all plots including the control; however background soil salinity was already above the agronomic threshold. Deep soil sampling (to 3 feet below ground surface [bgs]) did not indicate any clear trends related to treated and control plots. Fertilizer applications may also increase soil salinity; some types more than others. Composted poultry manure used at the Waterford site and potassium fertilizers used at the Orland site both contain salts. Fertilizers are generally applied in the tree row while the product used in this study was applied between tree rows with a 3-5-foot buffer on each side of the application strip.
- Soil Cl (Figure 3) – Soil Cl was also higher in plots treated with a higher rate of Dust-Off. Because Cl moves with water, it leached below the sampled zone quicker at sites with more rain. Cl accumulated in the 24-36 inch depth increment at the Orland and Waterford sites, but not at the Porterville site, where Cl was highest in the top 2 inches of soil. Porterville receives the least amount of annual precipitation of all of the plot locations.
- Deep soil sampling (Figure 4) – Soil samples were collected to the depth of the assumed active root zone of 3 feet at the end of the project. Results did not show any trends related to treatment rates of the MgCl product.
- Leaf tissue Cl (Table 1) – Leaf tissue Cl data showed that there were no treatment effects on almond leaf Cl concentration. Though random samples had Cl concentrations above the threshold of 0.25%, leaf tissue Cl at the Orland and Porterville sites were below this threshold on average. The Waterford samples averaged over this threshold in all treatments. Therefore, the product application was not an evident cause of the elevated Cl concentrations. The orchards at the Porterville and Waterford sites are grown on Nemaguard rootstock. This rootstock is known for its resistance to nematodes but it not particularly tolerant of salt ions, because it does not have the ability to exclude Cl from nutrient uptake. Lovell, which is the rootstock used on the Orland orchard, is similar in this regard. These are both peach rootstocks.
- PM 10 dust (Table 2) – Year 1 monitoring produced expected results; emissivity decreased as the Dust-Off rate applied increased. Compared to control plots, Dust-Off decreased dust emissions by 20 to 50% depending on the rate applied. Year 2 results were not as clear. There was not a clear association between rate and emissivity. This could have been caused by ambient conditions such as temperature and humidity that were different on application and/or monitoring days or different levels of ambient dust on monitoring days. Management practices that differed between years may have also contributed to the inconsistent results.

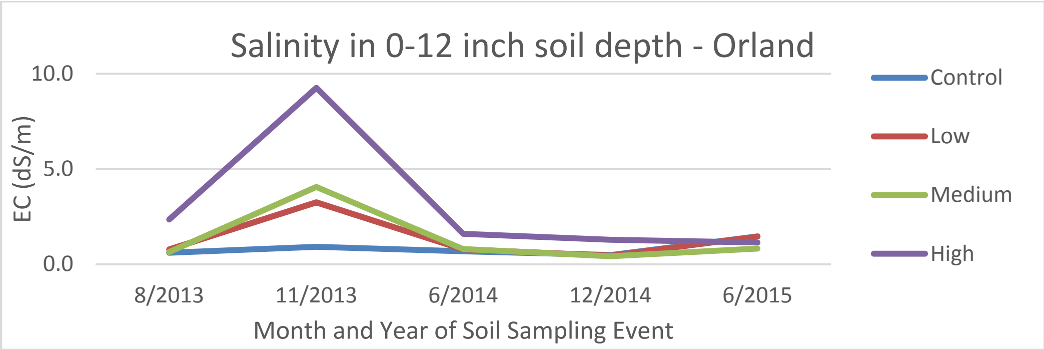


Figure 1. Average surface soil salinity by treatment of the Orland site throughout the duration of the project

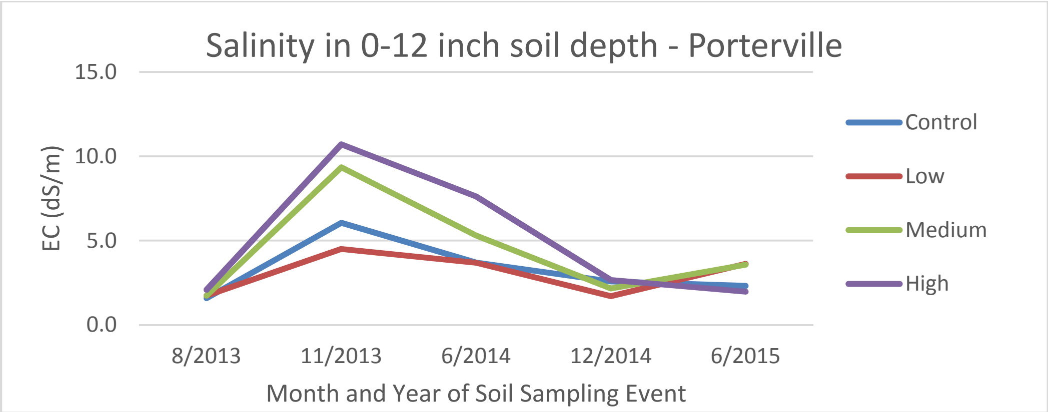


Figure 2. Average surface soil salinity by treatment of the Porterville site throughout the duration of the project

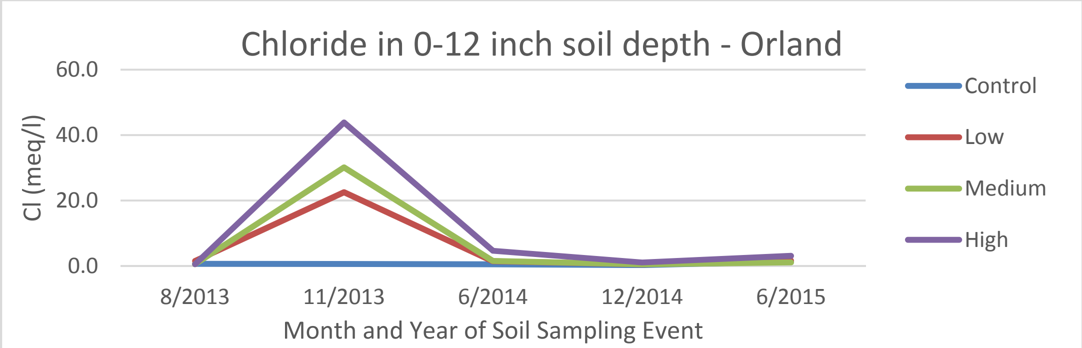


Figure 3. Average surface chloride concentration by treatment of the Orland site throughout the duration of the project

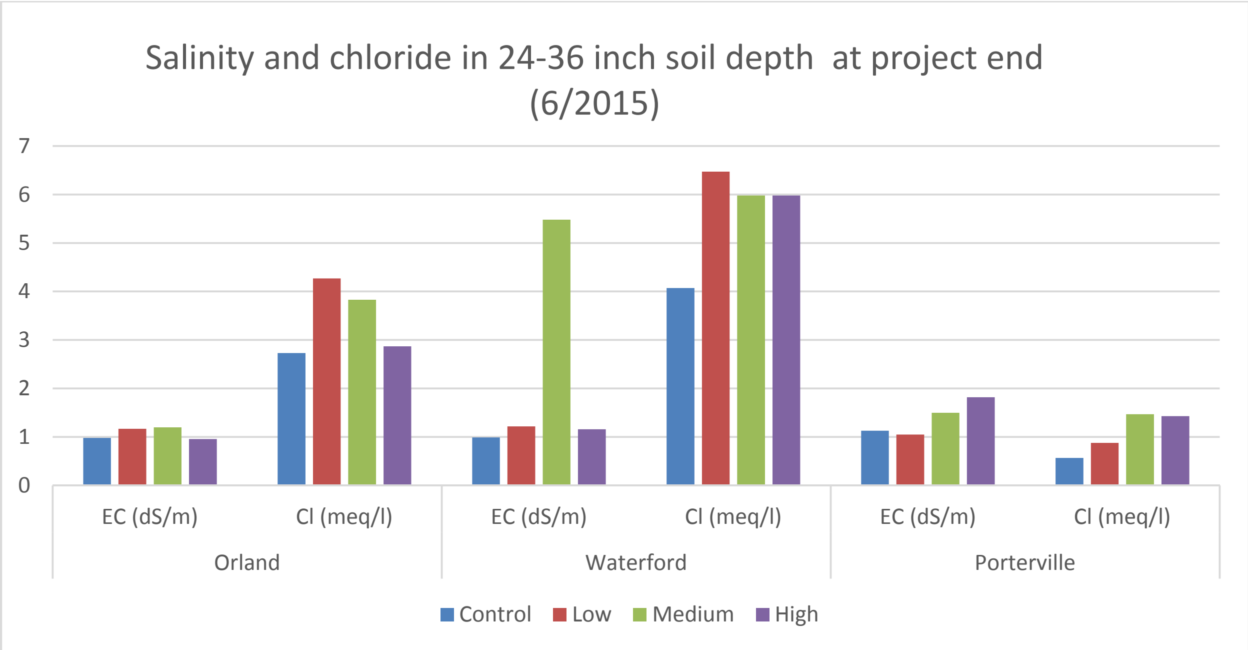


Figure 4. Average soil salinity (EC) and chloride concentration in the 24 to 36 inch depth of the tree root zone at project completion, June 2015 (10 months after most recent product application in August 2014).

Table 1. Percent leaf tissue chloride and magnesium in almond leaves at project end, June 2015.

Site	Constituent (%)	Treatment			
		Control	Low	Medium	High
Orland	Cl	<0.1	<0.1	<0.1	<0.1
	Mg	0.96	0.96	0.98	1.05
Waterford	Cl	0.33	0.33	0.43	0.37
	Mg	0.52	0.54	0.54	0.56
Porterville	Cl	0.10	0.10	0.10	<0.10
	Mg	0.68	0.68	0.63	0.65

Table 2. PM10 dust emissions in almond orchards at three study sites during the pick-up harvesting operation. Letters represent statistical significance between treatments; different letters represent statistically significant differences.

Site and Year	Control	Low	Medium	High
	(mg/m3)	(mg/m3)	(mg/m3)	(mg/m3)
Orland				
2013	13.5a	6.53b	5.36bc	4.9c
2014	13.0a	8.58c	11.1b	14.6a
Waterford				
2013	27.6a	18.1b	11.2c	12.0c
2014	NA	NA	NA	NA
Porterville				
2013	8.07a	6.39ab	6.14ab	5.81b
2014 (no product applied	20.0d	40.9a	35.1b	29.4c

This study was conducted on almond orchards only and did not benefit commodities other than specialty crops.

Project contributors included Land IQ (formerly NewFields), UC Davis, and Cargill. Land IQ was responsible for all aspects of project management and execution as well as coordination of project contributors. Land IQ personnel oversaw time and budget management of the day to day activities of the project, developed all project documentation, including study plan and semi-annual reports, performed all field work, and collected and managed field data. UC Davis contributed to the project by providing technical expertise and guidance for the development of the study plan, reviewing and interpreting study results, and planning any necessary modifications in field trial implementation and monitoring. Cargill personnel had three roles: assisting in developing appropriated rates for field trial treatments; coordinating and providing Dust-Off product for field trials, and performing statistical analysis of dust emissions results. The Almond Board of California provided administrative project management.

Goals and Outcomes Achieved

Performance monitoring included the following:

1) Dust emissions data collection – Dust emissions data were collected during three harvest operations (shake, sweep and pick-up) in 2013 and during two harvest operations (sweep and pick-up) in 2014 at each field study site. Shake was not monitored in Year 2 of the study because Year 1 results indicated that most of the emissions generated during shake process originated from the orchard canopy, not the soil surface. The relative proportion of dust generated during shake compared to other harvest operations was also relatively minor. Dust emissions data collected from treated plots and control plots allowed the comparison of dust emissions from treated soil and untreated soil. Comparing average emissions from replicated treatments determined the amount of dust reduction that resulted from each level of treatment. This activity supported the objective of determining the range of Dust-Off rates that provided adequate dust mitigation when compared to target reductions.
2) Soil data collection – Soil chemical and physical properties were measured before, during and after project completion. A full suite of analytes were analyzed in background samples to provide a baseline for

comparison after the soil was treated with Dust-Off. The background sampling also served to provide information on any unusual or remarkable soil qualities, of which none were found. Baseline salinity levels and Cl concentrations were compared against post-application salinity levels, and showed that both had returned to baseline levels at the end of the project. Soil sampling also showed that site soils differed in their silt to clay ratio, which has been indicated in previous studies on California almond orchards as a factor influencing emissivity. This activity supported the goal of determining the range of Dust-Off rates that are agronomically safe, when compared to the range of soil salinity levels and leaf tissue Cl concentrations that are acceptable for almonds.

3) Climate – Climate varied considerably between sites. Annual precipitation at the Orland site is approximately 30 inches per year compared with 6 inches per year at the Porterville site. Though precipitation was below normal during the project years, the influence of leaching rains on product residual was evident. By tracking precipitation on all sites, the influence of precipitation on soil salinity and product residual was clearer. This activity supported both goals of determining the effect of the Dust-Off product on soil salinity, and determining if there is adequate product residual through the winter season that might provide reduced dust mitigation the season after Dust-Off is applied.
4) Management – Some agricultural management practices have the potential to increase (or decrease) soil salinity. In this case, application of poultry manure at one site significantly increased salinity at the end of the first project year. Without tracking management practices, the increase in salinity might have been attributed to the Dust-Off product. This activity supported the performance goal of determining the effect of the Dust-Off product on soil salinity.

The main goal established for the project period was to determine a rate or range of rates at which Dust-Off could be applied to almond orchard floors to provide adequate dust mitigation while maintaining agronomically safe soil salinity and Cl levels. Though the study results were different in Year 2 than in Year 1, they showed what the “book-ends” should likely be for applying Dust-Off on almond orchard floors. The range of rates used in the study was neither too high, because it did not result in excessive residual at the end of the study, nor too low because it provided target dust emissions of 20-50%. This confirmed that rates that are much lower (at least one half) than municipal and industrial rates are appropriate and efficacious for agronomic use in almond orchards, where salinity does not exceed the threshold for yield impact. It is likely that this range of rates could only be further defined with site-specific information. As this study indicated, precipitation and soil type influence product efficacy and residual. Data also showed that the amount of C1 applied with the product is likely not significant compared to baseline levels of C1 and other salts applied through fertilization and irrigation waters; otherwise C1 would be correlated with treatment rates.

Typically, dust control performance is expressed as percent control, or the percent of dust emissions controlled with a suppressant compared to an untreated area. The goal was to determine a range of product application rates that would control dust while maintaining agronomic and environmental protection. Expected dust emission reduction targets (20-50%) were used to assess results. While specific dust control targets used to test dust control products in industrial and municipal applications are higher, these targets were considered both reasonable considering the reduced rates used on the almond orchards (compared to industrial and municipal rates) and considering results from other studies that investigated dust mitigation strategies in California almond orchards to date. Targets for salinity were to maintain soil salinity at or below 1.5 dS/m for EC (saturated paste soil extract); however, this should not be interpreted as an absolute threshold for salinity tolerance in almond because it is dependent on rootstock. Targets for safe Cl levels in soil are 5.0 meq/L (saturated soil extract) for almonds which is also dependent on rootstock and is not generally viewed as the guideline for determining Cl toxicity risk; however, leaf tissue Cl concentrations were compared to those from other relevant studies to evaluate their likelihood of posing risk to the orchard as leaf tissue concentrations are typically the benchmark for determining specific ion toxicity in almonds. Overall, dust emission reductions from treatments applied and monitored during Year 1 were on target; dust reductions were between 20 and 50%, as expected. During Year 2, the reductions in emissions from treatments were not within these targets for most treatments at most sites. This variability in results is often typical of field studies of short duration. More years of study would add to the conclusiveness of the study. Variability in results might be attributed to differences in ambient conditions at the time of product application and/or monitoring, such as temperature and humidity; differences in ambient dust conditions at the time of monitoring; differences in management practices on individual sites between years or differences in product mixture. Targets for agronomic safety (assessed by Cl concentration in leaf tissue samples) were met, while soil salinity targets were unclear because of fertilizer practices and the salt accumulation that occurs with long-term irrigation with high efficiency systems. However, treatment effects were not evident.

Beneficiaries

Beneficiaries of this project include

1) All California almond growers initially and may include other tree crop growers in time, especially since almonds tend to be less tolerant of salts compared to other tree nuts. Thus the findings are useful for other tree crops at showing the potential for dust reduction without injuring the trees. Also, tree crops grown in the San Joaquin Valley must contend with regulations of PM 10 emissions from agricultural field operations. Growers will benefit from an additional choice for controlling dust to reduce potential for further regulation, while improving air quality.
2) Farm workers who breathe in respirable dust during harvest operations. Additional methods to suppress dust during harvest have the potential to improve working conditions by reducing respirable dust. Participating growers of this study have already elected to use Dust-Off on orchard roads to reduce dust and increase visibility during harvest.
3) Air quality regulating agencies have new data and information to potentially add to their methods of dust control for voluntary CNMP programs.

There are over 900,000 acres of almonds grown in California statewide. Addressing environmental impacts improves the viability of the almond industry and potentially impacts land owners, growers, farm workers, haulers, hullers and shellers, packers, and all related to growing, marketing or living near almonds in California.

Lessons Learned

1) Dust monitoring technology – Laser photometers are well suited to this kind of applied research that takes place during actual field operations. They are reasonably precise (produce similar results over repeated measurements). Though their accuracy was not well established by air quality regulatory agencies during the literature review part of this project, measurements of PM 2.5 and PM10 during this field study agreed with results from other studies, indicating that emissions measurements were also accurate. The laser photometers used in the study do not measurable total particulate; they only measure up to 15 microns, which is not clear in their specifications. The larger particulates make up a significant portion of the visible dust from almond harvest and are what create nuisance dust situations.

2) Shake – The shaking operation during harvest (when nuts are mechanically shaken from the trees) did not produce enough particulate in the range of measurement (under 15 microns) to measure accurately. Most particulate that is released during shaking originated from the orchard canopy.

3) Product dilution – Though Dust-Off is formulated at a specific dilution for optimal efficacy, the product has been developed and tested largely for industrial and municipal applications where pre-wetting the ground surface prior to product application is the norm. During this study, Dust-Off application was improved by diluting the product because pre-wetting was not a practical option. Without dilution, the product tended to "bead" and not penetrate the soil.

4) Residual Efficacy – The initial intent of the project was to apply the product in each orchard for two consecutive years. However, based on soil sampling data collected prior to product application for the second year, a significant amount of residual product remained in the Porterville orchard which suggested that an additional year of application could be detrimental to tree health. In response, Dust-Off was not applied in this orchard the second year however the harvest operations were still monitored to investigate the efficacy of residual product to better understand if annual application was even necessary to obtain sufficient dust suppression. Based on the data from this one instance, the product was not effective at residual concentrations.

5) Field data – The number of field seasons required to collect enough emissivity data from which to draw strong conclusions about the optimal rates for almond orchard applications is likely more than two. Unlike highly controlled growth chamber or greenhouse studies, field studies encompass the wide range of variables typical of farming and rely on communication between many individuals, including field staff, custom harvest operators, and landowners. Because conditions are usually less than perfect, field study data is rarely conclusive with two years of data, and requires more years to confirm experimental results.

6) Silt to clay ratio – The silt to clay ratio is a parameter that has been found to correlate with dust emissivity in past almond orchard dust studies in California. This study confirmed that some sites are more emissive than others, and this emissivity likely does not depend entirely on texture or any one soil property alone. While silt to clay ratio likely played a part in how emissive each of the field sites was, there were no results that indicated that the efficacy of Dust-Off was affected by this parameter.

One unexpected outcome was the difference in results between the first and second field season. Though staff expected field conditions and study results to differ between years, the first year's results were expected and the second year's results were not. These overall results indicate that there are likely other factors, such as those affecting air quality (ambient dust conditions), soil (such as effects from fertilizer applications) and harvest equipment that may affect the application and/or performance of MgCl in agricultural settings. More years of field study would validate this assumption.

A second unexpected outcome of this project that is more practical in nature is that staff found that growers either used this product on orchard roads either prior to the study or as a result of the study. Having growers adopt MgCl application for roads is a form of participant feedback that does not require interpretation; growers trust in the efficacy of the product for orchard road use, though the rates they typically use is unknown, and possible run-off effects into orchards is also unknown.

Though this study provided a good indication of the "book-ends" for efficacious rates of MgCl, specific rates could not be confirmed within a two-year study because of the difference in results between the first and second years. Though the application and monitoring methods used were effective, more years of study are required to refine these rates.

Additional Information

See attached for Appendix 1.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 38	**Project Title:** Life Cycle Assessment of Air Emissions and Greenhouse Gas Offset Potentials in Perennial Fruit and Nut Crops	
Grant Recipient: The Regents of the University of California, Davis, Agricultural Sustainability Institute	**Grant Agreement No.:** SCB12038	**Date Submitted:** December 2015
Recipient Contact: Sonja Brodt	**Telephone:** 530-754-8547	**Email:** sbbrodt@ucdavis.edu

Project Summary

Prior to this project, little was known about the magnitude of greenhouse gas (GHG) emissions from tree crops such as deciduous fruit and nut crops, nor about the potential for using the woody biomass and other co-products such as hulls and shells to offset those emissions. In addition, little was understood about which practices or areas of orchard management contribute the most emissions, from a life cycle perspective (tracing back to acquisition of primary materials needed for all material and energy inputs to the orchard). Previous research on life cycle emissions and offsetting potential has focused on Midwestern grain crops and rice and dairy in California. The purpose of this project was to provide life cycle assessments (LCA) of greenhouse gas (GHG) and other pollutant emissions for walnuts, almonds, peaches and prunes, and quantify the potential for orchard and biomass management to offset emissions.

Implementation of California's Global Warming Solutions Act of 2006 requires significant reductions in greenhouse gas emissions across sectors. Orchard production systems both emit GHGs as well as sequester carbon through substantial woody biomass accumulation. Quantifying the emissions as well as sequestration and offset potential will assist policy makers and orchard crop growers to better understand how orchard crops fit into the broader landscape of emissions and carbon offsets in California and what practices to focus on for emissions reductions. It also provides a statewide picture of the importance of agricultural biomass in reducing the overall greenhouse gas footprint of these cropping systems, which can help inform policies regarding biomass utilization options. In addition, buyers of California fruit and nut crops in the United States and abroad are increasingly interested in GHG footprint (or carbon footprint) information. Until this project, only incomplete information and unsubstantiated assumptions were available to guide sourcing decisions for buyers, including consumers.

This project was, in part, built upon 2010 Specialty Crop Block Grant Project 47: *Carbon dynamics of orchard floor applied chipped almond pruning as influenced by irrigation methods, soil type, cover crop management and farm practices.* The literature review and modeling work on the potential impact of chipped prunings on soil carbon sequestration, played a key role in informing the biomass and LCA model development. Geographic Information System (GIS) database on almond acreage also formed a basis for the geospatial model development, to which more data was added about the additional tree crops in the study and current locations of bio-energy facilities. This project provided information about on-farm pruning management practices and their modeled impacts on GHG emissions. This project situated these results within a more comprehensive, geospatially informed LCA model, that helped account for the additional off-farm impacts accrued by those on-farm practices (both upstream, in the case of farm inputs, and downstream, in the case of end-of-life biomass management). Only this comprehensive approach enabled the tree crop industry

and policy makers to ascertain whether on-farm changes in practices to reduce emissions inadvertently cause additional emissions upstream or downstream from the orchard.

Project Approach

The focal activity of this project was a full life cycle assessment-based accounting of greenhouse gas (GHG) emissions and credits resulting from production of four crops, almonds, walnuts, peaches, and plums, on a statewide basis. Quantification of emissions was accomplished through the following tasks:

Identify all the types and amounts of inputs (material and energy inputs) required annually for one acre of production of each separate orchard crop. Project staff utilized University of California, Davis Cost of Production studies (http://coststudies.ucdavis.edu/en/) for initial cataloguing of all inputs and equipment operations; and verified their validity and current accuracy by following up with growers, Cooperative Extension Farm Advisors, and other industry experts for feedback. In the cases of peaches and plums, information for both fresh market and processing fruits was compiled. This project also included a case study of a certified organic walnut farm with an on-farm shelling facility run on bio-energy produced on site. Information on inputs and equipment operations was gathered directly through interviews and checking of relevant business records with the owner/operator and his staff.

Identify and quantify all orchard outputs, including standard crop yields as well as all co-products and their uses. Crop yields were initially identified from the most recent Cost of Production studies, but were verified and adapted based on feedback from growers, Farm Advisors, and commodity board staff. A key co-product from all crops includes the woody biomass from orchards, especially that resulting at the end of the orchard's lifespan when trees are removed. According to industry experts, including communications with orchard removal companies, in any given year, up to 95% of this end-of-life biomass gets chipped and sent to biomass power plants located throughout the Central Valley where the vast majority of these orchard crops are produced. Orchard crops also generate pruning biomass, often on an annual basis. Based on published literature, as well as personal communication with growers and commodity experts, it is assumed that 50% of this biomass is burned in the field, and 50% is chipped and mulched in the orchard. Additional important co-products analyzed in this project include almond hulls, used as dairy feed, and almond shells, walnut shells, and prune pits, used for bioenergy (50% of shells).

Develop life cycle inventory data for contracted orchard operations for which detailed materials and equipment data are lacking in the Cost of Production studies**.** These include nursery operations, pollination services, custom harvesters, and orchard clearing companies. Life cycle inventories for the latter two operations were already developed for almonds based on surveys and phone interviews of a sample of operators, and these life cycle inventories were adapted for this project to each of the other crops, accounting for differences in yields and biomass accumulation. Data to account for pollination operations were adapted from a prior study on GHG emissions in honey production (Kendall et al. 2012a), and data on sapling production in nurseries were adapted from a previous nursery study (Kendall et. al 2012 pounds).

Collect and analyze biomass accumulation data. Tree cross-section and canopy data were collected from almond, walnut, and peach orchard blocks slated for clearing. These data along with data on biomass weights obtained from clearing companies after clearing was completed, allowed for development of biomass accumulation models for the different crops, starting with already-modeled almond growth characteristics, which were adapted to the other crops based on literature, verification from orchard crop experts and known tree spacing. The walnut model was further refined based on destructive sampling of a few individual orchard trees being removed in a grower's orchard.

Collect and analyze sample soil Nitrous Oxide (N_2O) emissions data. Nitrous Oxide fluxes were measured for two years in an organically managed walnut orchard and in a conventionally managed prune orchard. During this period, one-hundred and fifty and one-hundred and seventy-one flux measurements were conducted at the walnut and prune sites, respectively (Appendix Figures A1 and A2). The gas samples were processed on a gas chromatograph and the cumulative N_2O emissions were calculated under the assumption that the measured N_2O fluxes represented daily fluxes and that fluxes changed linearly in between measurements. The N_2O emissions under the trees were compared with those in the alley, or tractor rows, and emissions were separated into those occurring during the irrigation and rainy seasons. The emissions were expressed in Carbon Dioxide (CO_2) equivalents using a global warming potential conversion factor of two-hundred and ninety-eight (298 kg CO_2 equals to 1 kg N_2O) according to Intergovernmental Panel on Climate Change (2013) guidelines. In addition to the gas flux measurements, the nutrient inputs (organic soil amendments and synthetic fertilizer) recorded for consideration in the LCA calculations, and soil inorganic N, moisture and temperature were periodically measured at these sites using standard soil analysis methodologies.

Develop geospatial model to account for spatial distribution of orchards, irrigation and transport infrastructure, and bioenergy facilities that utilize orchard biomass. Google Earth and ArcGIS (Geographic Information System software) were used to calculate transport distances between orchard and bioenergy facilities, as well as to map surface water irrigation infrastructure and depth of groundwater resources. Orchard crop spatial distributions were obtained from the United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS) Cropscape dataset; groundwater depth data across the Central Valley were obtained from the California Department of Water Resources; surface water energy zones were determined using data on canal and aqueduct infrastructure as well as the Cropscape dataset and aerial imagery from Google Earth; and data on the prevalence and pressurization requirements of different irrigation systems (flood/furrow, sprinkler, microsprinkler, drip) were obtained from interviews with University of California Cooperative Extension (UCCE) farm advisors. The end result was energy use values for delivery of irrigation water per unit volume, specific to crop type and location within the Central Valley. Information from these transportation and irrigation analyses were incorporated into the life cycle assessment models to calculate associated GHG emissions.

Assemble life cycle inventory and impact datasets. Project staff used ISO 14040 life cycle assessment standards to assemble the GHG impacts of all the material and energy inputs, relying on a number of published life cycle inventory databases for common material and energy inputs, including the ecoinvent database, the GaBi Professional database, and the United States Life Cycle Inventory (LCI) database. Life cycle assessment models were developed in Excel for each separate crop. For peaches and plums, separate models were developed for fresh market and for processing fruit crops, and the results were then combined into one statewide peach and plum (or prune) average, respectively, by weighting the individual sub-crop according to percent of total crop acreage it occupies.

Gather input from growers and other industry leaders. Early on in the project, project team have published an article to announce the work and invite feedback in Orchard Notes, a grower-focused Cooperative Extension newsletter for Sutter and Yuba counties. A press release was sent out and a blog post was created with similar information (although no feedback was directly garnered through these means). Ten key informant interviews were conducted over the course of the project, three with industry experts including Farm Bureau staff, Dried Plum Board staff, and Resource Conservation District staff, and the remaining seven with growers of the four crops. Numerous on-going discussions were held with the staff of the Almond Board of California regarding the direction of the research, how results are presented, and future research directions. All of these open-ended discussions allowed the project team to gain a better understanding of growers' primary areas of interest with regards to energy use, carbon foot printing, and orchard management, how to better present our results to an agricultural audience, and where this work could make a difference. These insights guided in making important changes in what types of alternative practices were modeled in the system, how to present the work visually and in writing, and what topics to emphasize in outreach activities and materials.

Conduct outreach to growers and industry leaders to disseminate results. Project staff either participated in or led in the following activities:
May 2014: Gave presentation of preliminary results at Almond Board field day in Newman, California to approximately eighty attendees.

June 2014: Gave presentation of preliminary results to the Board of Directors of the Almond Board.
December 2014: Almond Board of California annual conference included one-hundred and fifty to two-hundred attendees.

March 2015: Provided one-and-a half hour presentation and feedback session at California Climate and Agriculture Summit, which included approximately twenty-three attendees.

April 2015: Gave handout and brief talk on results at Sustainable Cotton Project field day for growers transitioning into orchard crops to fifty attendees.

June 2015: Met with three leaders of the California Dried Plum Board to follow up with more refined results

July 2015: Held a live webinar on project results, also posted recording to project webpage. This included fifteen attendees.

Summary of key research findings:
The most salient results from the LCA models include the following:
Nutrient management (including on-farm application but also manufacturing and sourcing of fertilizers) and irrigation management (including upstream sourcing of water as well as on-farm pumping and pressurization) account for the largest portions of overall life cycle energy use and GHG emissions, from 12% to 36% for nutrient management, and from 11% to 20% for irrigation management, depending on the crop.

Given the large quantities of orchard biomass generated over the long lifespans of these crops, use of this biomass in bioenergy generation can contribute substantially to offsetting orchard GHG emissions and energy use, providing a large base for potential future carbon credits.

Impacts differ substantially across different regions of the state, especially due to large differences in irrigation energy intensity, which can vary up to five fold or more across the Central Valley, based on large differences in proportion of gravity-fed surface water versus pumped surface-water versus pumped groundwater that is used for irrigation. Therefore, renewable energy technologies such as solar pumps, to reduce the fossil fuel use in pumping groundwater, will be especially effective in reducing the overall emissions, as will choosing surface water sources over groundwater whenever feasible.

A case study of an organic walnut production system in the Sacramento Valley highlighted a number of practices that could potentially be applied more broadly in California orchard production for reduction of GHG emissions. This operation uses poultry manure sourced from within an approximately fifty mile radius for fertility management. Despite the large quantity required per year (approximately 2.5 tons per acre) and the need for fuel combustion in equipment use for manure spreading, the total nutrient management related GHG emissions for the organic system amounted to only about 60% of nutrient management related emissions in the conventional system. This difference is due to the treatment of manure as a waste product of poultry farming (hence it was assumed that production of the manure does not incur any emissions that can be attributed to the orchard system) as well as the energy-intensive nature of synthetic fertilizer production. This difference holds despite the fact that directly measured GHG emissions (CO_2 and N_2O) from the organic orchard soil were about 3.5 times greater than that of the conventional orchard. Additionally, the organic orchard utilizes a number of renewable energy technologies in hulling and shelling – in particular a modular gasification-pyrolysis system (Community Power Corporation BioMax 50) that generates electricity, producer gas, and heat from walnut hulls, displacing fossil-fuel intensive grid electricity and propane production as well as generating long-term carbon storage in the form of a biochar coproduct. This technology and a solar power array allow the organic hulling/ shelling operation at this orchard to generate 8.7 times more credits for fossil fuel displacement than a conventional orchard (see Additional Information for graphical results).

This project did not benefit commodities other than specialty crops as it focused entirely on impacts associated with parameters very specific to tree crop management.

PI and co-PI oversaw the LCA modelling work conducted primarily by graduate student researcher. PI also coordinated all pieces of the project to ensure that all research and outreach components became available when needed. Co-PI oversaw the biomass accumulation data gathering and modeling, and co-PIs supervised completion of the soil N_2O emissions measurements. PI conducted and oversaw most of the outreach and feedback activities. Collaborating Farm Advisors assisted in identifying field sites for soil emissions work and identifying growers for meetings to gather input and feedback, and provided opportunities for the project to publicize information through their newsletters. Collaborating organization California Climate and Agriculture Network (CalCAN) worked with the University of California, Davis team to produce two factsheets about LCA and orchard GHG emissions, and is working to distribute them to relevant state agencies such as the Air Resources Board, California Department of Food and Agriculture, and a range of organizations working on agriculture and climate change issues. CalCAN also provided a venue for a focused workshop on this project at its biennial climate and agriculture summit in 2015. Pacific Coast Producers provided access to peach grower contacts and peach processing data.

Goals and Outcomes Achieved

Measurable outcomes included the following: Increasing the understanding of approximately 900 California tree crop growers of the GHG emissions and fossil energy impacts of orchard crop management and methods to reduce these impacts.

Achieving this outcome required first to successfully complete all the fieldwork and other data components required for the LCA models for peaches, plums, almonds, and walnuts, and completing the construction of the LCA accounting models. This work was successfully completed. The second step to achieving this outcome was to publicize the results of the models to growers and others in the orchard crops industries. Through the range of outreach events described above, project staff have to date directly reached at least 335 attendees, of whom were 75% growers, with the remaining attendees being extension, orchard crop commodity board leaders, regulators, researchers, and others. The first academic journal publication, which focused on the almond LCA results, also generated a substantial number of news stories in publications such as the Western Farm Press, Capital Press, the Daily Democrat, and others, that reached a countless number of growers, consumers, and other industry stakeholders, based on the circulation figures for each of these publications.

Specific growth in awareness and understanding of orchard emissions was tracked with a survey during the project workshop held at the CalCAN Summit in 2015. Participants self-assessed their own level of knowledge about GHG emissions and energy efficiency in orchard crop production. At the end of the workshop, fourteen out of sixteen respondents chose a 3, 4, or 5 on a 1 to 5 scale of how much they learned about GHG emissions, and ten out of fourteen chose a 3, 4, or 5 for how much they learned about energy efficiency, demonstrating the educational value of the project results. Project staff have also attempted to assess grower awareness more indirectly through telephone surveys of thirty University of California Farm Advisors, Extension Specialists, Resource Conservation District (RCD) and Natural Resource Conservation Service (NRCS) staff who specifically work with orchard crops during 2014 and 2015 years. Only two indicated that they received any inquiries from growers about GHG emissions, while about half indicated that they had received grower inquiries about energy efficiency. Since many of the key outreach activities and products occurred in the last to two to three months of the project period, project team were not able to use this survey method to measure change in grower awareness or interest in these topics as a direct result of the project, since the survey work needed to be completed simultaneously. However, the results do generally suggest a relatively strong interest level in on-farm energy efficiency among orchard crop growers, and very little interest in GHG emissions.

At least 5% of California policymakers and regulators will increase awareness of the net GHG offsets possible from tree crops and will understand how using comprehensive LCA methods can determine emissions offset potentials, pollution trade-offs, and planning requirements for alternative uses of tree biomass.

In collaboration with the California Climate and Agriculture Network (CalCAN), two project factsheets were produced:

Life Cycle Assessment: A Tool for Assessing the Environmental Impacts of Farm Crops. This fact sheet provides a description of the LCA method generally, the challenges and limitations of LCA models, and how they can be used to inform agricultural management decisions.

Carbon Footprint of Five California Orchard Crops. This companion fact sheet outlines the method used to produce the orchard LCA models, summarizes key findings, and provides an overview of the study implications for policy, practice, research needs and other decision-making opportunities.

These factsheets are in the process of being distributed in the following ways: Posted on the CalCAN website and the University of California, Agriculture Sustainability Institute (ASI) website. Summarized in a CalCAN newsletter, with links to the website. Distributed to key staff at the California Air Resources Board which is responsible for achieving California's greenhouse gas emissions reductions target. Distributed to the California Department of Food and Agriculture Environmental Farming Panel members. Distributed to key staff at California's Department of Conservation.

In addition, the on-demand webinar recording highlighting key project results is being posted on the ASI webpage specific to this project, and the link **(http://uc-d.adobeconnect.com/p3m4uzxsqhk/**) has been sent to over one-hundred growers, regulators, extension staff, orchard commodity board staff, and researchers. Links to this material will continue to be shared with relevant audiences as opportunities arise in the upcoming months.

Increasing awareness and providing information to growers and policymakers/regulators are both long term outcomes. As noted above, project staff have directly achieved at least one-third or more of the original grower target, and likely more through secondary connections such as news articles that are reporting on the work. Project staff are anticipating that this work will be ongoing after the end of the project period through independent efforts and through partner CalCAN, who will be continuing to circulate the factsheets during the ongoing course of their work on GHG emissions and climate adaptation in agriculture, as well as forward the webinar recording.

Project staff have completed all orchard biomass and soil emissions fieldwork as planned. Orchard input data was collected and verified their representativeness with Farm Advisors, growers, and other industry experts. Transportation, irrigation, and bioenergy facility sub-models were collected as planned. Project staff have developed statewide LCA models for each of the four crops that utilize all of the above-mentioned pieces as inputs, and used these models to calculate baseline gross emissions, credits, and net per acre energy and GHG footprints on a statewide basis for each of the four orchard crops, up to farmgate, and in some cases also for basic postharvest handling. The organic walnut case study model is also almost complete, and is just undergoing a process of error checking to verify results, which will be completed by the graduate student researcher and project PIs in the next several weeks. Feedback and input was gathered throughout the course of the project, as planned, from selected growers and industry leaders. Project staff have created all planned outreach products, two policy-oriented factsheets, webinar, and project website; and held a workshop at the CalCAN Summit. The audience of twenty-three attendees included three to four growers, as well as five researchers, one extension professional, one government agency staff member, food company and retail/wholesale representatives. (The remainder did not state their affiliation.) Only in the area of direct grower outreach have the accomplishments fallen short of proposed project targets, as detailed above, keeping in mind, however, that indirectly, through commodity board partners and others, the reach will be far greater. In addition, outreach on this project will continue beyond the project period as the graduate student researcher is completing PhD work based on the research conducted for this project, which will require more academic publications. In addition, this project falls within a key initiative area of the Agricultural Sustainability Institute, and will be included in a greater outreach push in the upcoming months, especially via refinement of information resources for the website.

This project has developed five sets of LCA models that account for baseline life cycle energy use and greenhouse gas emissions (including credits from use of co-products such as woody biomass in other industries) in conventionally grown peaches, plums, almonds, and walnuts, and organic walnuts with on-farm biopower generation (case study of one operation). In addition, these results can be used to analyze the impacts of changing specific practices, and will thus be useful research tools going forward. Project team have published a two-part paper on the results from the almond model in the Journal of Industrial Ecology, and have created two policy-oriented factsheets, an online webinar, and a project website highlighting key results. Project staff have directly reached between three-hundred to four-hundred stakeholders, including many orchard crop growers, extension, and commodity board staff, as well as government regulators and agricultural program staff, with information about the importance of a life cycle assessment approach to understanding GHG emissions and energy use in agriculture, and with key results from the models. No lobbying was conducted.

Beneficiaries

The beneficiaries are California peach, plum, almond, and walnut grower, as well as food companies and consumers worldwide who purchase these crops. California regulators, non-governmental organizations, regulators working on developing GHG offset protocols for agriculture, and irrigation and nutrient use efficiency and renewable energy incentive programs for orchard crop growers will also be able to use the information obtained from this project.

There are approximately 15,000 peach, plum, almond, and walnut growers in California, utilizing over 1,700,000 acres of the Central Valley. Understanding the emissions profiles of their crops will allow these growers and their respective commodity programs to implement more scientifically sound sustainability programs, that will also help prepare them for potential future climate-related regulations, as well as improve their product image to buyers and consumers, and thus potentially increase their marketing advantage. The Almond Board of California is already using project results in their own publicity efforts. The potential economic impacts in terms of marketing advantage are unknown at this point. Moreover, if the orchard industry is able to implement more GHG reduction and offsetting strategies, then the entire population of California will benefit by avoiding negative economic impacts due to climate change.

Lessons Learned

Some of the lessons learned included:

Building multiple LCA models for similar types of crops is an efficient approach to getting results for many crops at once since one model can serve as a template to build the subsequent ones, with relatively small changes needed to account for the minor differences between crops.

Utilizing GIS sub-models to feed geographically differentiated data into LCA models is a good way to account for substantial variations in crop production across different regions, and helps to make LCA models more accurate, avoiding faulty assumptions of cropping system homogeneity across large areas.

Grower and industry feedback can often be put to best use approximately mid-way or more through the modeling process, when some preliminary results have already been obtained to give growers something to respond to, but before models are finalized.

Working on a topic that engenders skepticism and doubt from many agricultural stakeholders (e.g. climate change) requires careful thought and planning to obtain useful feedback from the industry, and for outreach.

The most unexpected result from the life cycle assessment work was the magnitude of the current contribution made by bioenergy utilization of orchard biomass in offsetting GHG emissions resulting from an orchard's entire life span; and furthermore, the potential that exists for increasing this offset even further, so that some orchards might even be close to having a net zero GHG, or "carbon" footprint.

Although not quite unexpected, another somewhat surprising result is the very large difference in energy intensity of irrigation in different regions of the California state, depending on proportion of surface water versus groundwater used, depth of groundwater, and other factors. The southernmost and westernmost areas of the San Joaquin Valley require more than five times as much energy to supply their orchards with water as most areas in the Sacramento Valley, and some areas with riparian water resources in the San Joaquin Valley. Given that irrigation management, including on and off farm components, accounts for up to 20% of the total GHG emissions of orchards, understanding the energy use and GHG implications of orchard location is important.

One of the goals that was not fully achieved: Project staff were unable to complete as much direct grower outreach as originally anticipated, primarily due to the challenges of drawing attention to a topic (GHG emissions) that is not a high priority, or any priority, for a large section of the orchard grower population in California; and moreover is closely related to a topic (human-driven climate change) which still engenders either outright skepticism or at least uncertainty among many members of our target audiences. For example, several of the key informant interviewees explicitly voiced doubts about climate change and/or a human role in climate change. Some planned events, such as presentation of this project's results in an annual Prune Growers meeting in the Sacramento Valley, had to be cancelled due to higher priority topics getting placed on the meeting agenda and concerns from the organizer that many of the attendees might not engage well with this project. The results of this project are probably of more interest at the policy and regulatory level, and to large industry groups such as the Almond Board, who are actively moving forward on addressing climate and agriculture issues. In order to engage the mainstream of growers around this topic, it is suggested to link it to other currently more pressing topics, such as energy efficiency and nutrient and water use efficiency, all of which currently have regulatory programs and/or incentive programs for growers to address them. Project staff also suggest further education of agricultural stakeholders on the science and evidence of climate change and projections for future impacts of climate change on agriculture. In addition, finding those leaders in the agricultural community who are dedicated to addressing climate change issues, and working with them to disseminate knowledge, is important. This work identified that there are several leaders like this in the orchard crops industry.

Additional Information

Academic publications:

Kendall, AM, Marvinney, E, Brodt, S, Zhu, W. 2015. Life Cycle-based Assessment of Energy Use and Greenhouse Gas Emissions in Almond Production, Part I: Analytical Framework and Baseline Results. Journal of Industrial Ecology, DOI: 10.1111/jiec.12.

Marvinney, E., Kendall, AM, Brodt, S. Life Cycle-based Assessment of Energy Use and Greenhouse Gas Emissions in Almond Production, Part II: Uncertainty Analysis through Sensitivity Analysis and Scenario Testing. Journal of Industrial Ecology, DOI: 10.1111/jiec.12.

Websites: www.asi.ucdavis.edu/programs/sarep/research-inititaves/are/energy/lcaorchard
Recorded webinar: http://uc-d.adobeconnect.com/p3m4uzxsqhk/

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 39	Project Title: Cultivar trait selection to improve tomato water use efficiency and yield under low water availability	
Grant Recipient: The Regents of the University of California, Davis	**Grant Agreement No.:** SCB12039	**Date Submitted:** December 2015
Recipient Contact: Louise E. Jackson	**Telephone:** (530) 754-9116	**Email:** Lejackson@ucdavis.edu

Project Summary

Processing tomato is a very important specialty crop in California. Its vulnerability to water shortages is a big issue during these current times of drought, and also for the future, given projections of greater frequency and severity of drought due to climate change. The premise of this project is that the sustainability of this crop depends on incorporating new traits that ensure production under the more drought-relevant water management regimes of the future. By seeking crop traits of interest to farmers and seed companies, and working collaboratively with a seed company, this project directly provides information and crop germplasm to the stakeholders who will be responsible for addressing these challenges.

The Sacramento and San Joaquin Valleys of California, with a Mediterranean-type climate, produce 90% of the processing tomatoes in the United States. This is a water-intensive process typically requiring from 42 to 74 cm depending on location, year, and irrigation management system (i.e., furrow vs. subsurface drip). Predicted decreases in annual precipitation along with lower Sierra Nevada snowpack, will force growers to either alter their tomato management (i.e., use new drought tolerant varieties, alter irrigation practices, or decrease production acreage) or transition to new crops.

When faced with a drought year in California, tomato growers have several options. A common response is to decrease the planted acreage and apply the typical amount of water to each crop field. Alternatively, they could reduce the irrigation applied per field to increase the planted acreage, using one of these three approaches. The first approach (full water inputs) involves planting the field in the expectation that adequate water will be found from a combination of sources such as allocated surface water, ground water sources, and/or purchased water from other growers or water rights holders. Second (full season deficit), growers may plant the fields with the intention of reducing water inputs throughout the growing season, while sacrificing yield to some extent. Third (terminal deficit), they may irrigate the field sufficiently through plant establishment before initiating deficit irrigation later in the growing season, as dictated by water available for irrigation.

Neither current tomato hybrids nor their parental inbred lines have been explicitly selected for high performance under water deficit. Wild species and accessions of tomato possess untapped sources of new genetic variation and other researchers produced a genetic library of the *S. pennellii* Cor. (a wild species found in arid climates) genome in the background of the M82 cultivar, which is already known to be drought resistant. The result is many introgression lines (ILs) each containing a very small segment of a chromosome from the wild species in an already drought resistant cultivar. Thus, the effect of small sets of *S. pennelli* genes in the IL genotypes relative to the background cultivar M82 may show morphological, developmental, and/or physiological traits that convey advantages under low water availability.

The importance of learning to manage tomatoes under low water availability has been sharply illustrated by the record setting drought in California. In addition to examining different irrigation management approaches i.e., full irrigation, full season deficit irrigation, and terminal season deficit irrigation as described above, this project introduced the possible use of wild tomato species' genetic material in breeding for tomatoes with improved characteristics under low water availability, a long-term solution to growing tomatoes under low water availability that has not been widely practiced by large seed companies. This project evolved to have a strong collaboration with a seed company, and results are thus directly available to plant breeders.

This project built upon 2009 Specialty Crop Block Grant Program Project 14: *Implementing the Partial Root Drying Technique to Increase Water Use Efficiency for Processing Tomatoes* in which an irrigation method using furrow irrigation by which water inputs could be greatly decreased without yield loss was tested. It also increased awareness for drought preparedness via management and crop breeding. Four on-farm field trials and a trial at a seed company all showed a reduction of 25% in applied water via alternate furrow irrigation (irrigating only one furrow along each bed, and alternating sides each irrigation event) with no decrease in photosynthesis or yield. This 2012 project built upon the results of the 2009 project by expanding the research into managing tomatoes under drip irrigation, which is used by a greater proportion of the tomato industry than furrow irrigation. The 2012 project also brought in experimental genotypes that possess genetic material from wild species that might convey better performance under water deficit than is found in current production tomato genotypes.

Project Approach

<u>Grower survey on water use efficiency in processing tomato (OBJ1a, OBJ1b, Obj1c, and OBJ2a)</u>

After consultations with University of California (U.C.) extension personnel, surveys on water use efficiency in tomatoes were prepared and sent to growers (OBJ1a). Nearly 30% of surveys were returned for analysis (OBJ1b). Growers expressed particular interest in several processing tomato varieties. They also were interested in traits that might improve heat tolerance during flowering, chilling tolerance during early growth, and traits that might confer resistance to diseases related to water stress, such as blossom end rot (OBJ1b). They might change their crop management if tomato varieties with better performance under water stress were available (OBJ1b). This information in conjunction with many interviews with additional growers and farm advisors resulted in the identification of several tomato varieties and potential crop traits to be included in the field study (OBJ1c). Lengthy discussion with researchers and industry tomato breeders also led to the identification and addition of several specialized tomato lines that incorporate genes from desert- and alpine-adapted wild tomato species into the planned field trials (OBJ1c). These tomato introgression lines (ILs) were included to investigate the potential benefits of adding these traits into processing tomato breeding lines, and were of particular interest to industry plant breeders (OBJ2a). Project staff incorporated the suggestions from the grower survey and breeders in the research plans, and sought out and found experimental ILs that were thought to convey many of the potential benefits in which these stakeholders were most interested.

<u>Harris Moran (H.M.) Clause Seed Company field trial 2013: full irrigation control vs. full season 20% of control deficit irrigation treatment (OBJ2b and OBJ2c)</u>

Several different sets of ILs were selected that may possess specific traits that might improve production under deficit irrigation (OBJ2a). The main focus was on processing tomato cultivar M82 (*S. lycopersicum* cv M82) and three ILs with an M82 background and genetic material from *S. pennellii* (IL2-1, IL5-4, and IL9-1) (OBJ2a), but other ILs and high yielding cultivars were also included. A field trial was designed and planted at the H.M. Seed Company (OBJ2b). It was comprised of 14 genotypes (six production hybrids and eight experimental IL genotypes) grown under a full irrigation treatment (control) and a 20% of full treatment (deficit) that was started once the plants were established (OBJ2a and OBJ2b). Having the field trial under their supervision meant that field management was closely aligned with the industry standard (OBJ2b). An on-farm or trial grown on a UCD field station would not be as widely accepted due less precise management.

Frequent measurements during the growing season were made of gravimetric soil moisture, plant stress (photosynthetic rates, stomatal conductance, and physiological water use efficiency (WUE- photosynthetic rate/transpiration rate)), canopy cover with an infrared digital camera, canopy temperature depression (CTD; the difference between plant canopy temperature and air temperature), and leaf water content (OBJ2b). Leaves were analyzed for $\Delta^{13}C$ as an indirect measure of WUE. Shoot biomass and agronomic data (i.e., yield, fruit pH, color, soluble solids (Brix), crop WUE (WUEc), harvest index (HI), and negative fruit quality measures including blossom end rot (BER), rotten and sunburned fruit), were collected during harvest. Fruit quality measurements were conducted by H.M. Clause Seed Company (OBJ2c). The number of samples and the details of the methods are given in Attachment 1. Results from the first set of analyses of the 2013 trial were shared immediately with H.M. Clause Seed Company and several interesting traits have been identified at this early stage of the analysis that generated strong interest by plant breeders at H.M. Clause Seed Company, as will be discussed below (OBJ2c).

The 2013 season deficit irrigation treatment, with its pronounced and continuous water shortages, decreased plant size and yield relative to the control by 30 to 40 percent at harvest, which was from late July to mid-August; depending on the genotype (M82 and IL2-1 were harvested in late July and early August while IL5-4 and IL9-1 were harvested later into August) (OBJ2c). For example, yield of the background cultivar, M82, was reduced by one-third under deficit irrigation (66. 7 ± 6.6 and 44.1 ± 6.2 tons ha^{-1} for control and deficit irrigation, respectively). Due to M82's small size (0.17 ± 0.01 kg $plant^{-1}$ and 0.11 ± 0.03 kg $plant^{-1}$ for the control and deficit, respectively) its HI (0.52 ± 0.01) was higher than all the ILs under the control treatment (0.42 ± 0.04, 0.26 ± 0.03, 0.42 ± 0.01 for IL2-1, IL5-4 and Il9-1, respectively). Both IL5-4 and IL9-1 were larger than M82 under both the control (0.45 kg $plant^{-1}$, and 0.28 kg $plant^{-1}$, for ILs 5-4 and 9-1, respectively) and deficit (0.30 kg $plant^{-1}$ and 0.22 kg $plant^{-1}$, for ILs 5-4 and 9-1, respectively) treatments. Yet larger biomass in these ILs did not result in higher yields than M82. IL2-1, a similarly small genotype, had lower yields than M82 in the deficit treatment. High WUEc was typical of M82 (2.86 and 10.1 tons ha^{-1} cm^{-1} applied water under the control and deficit treatments, respectively). WUEc for M82 was 35 percent higher than any IL under both irrigation treatments. But fruit size was generally similar among the genotypes, except for larger fruits in M82 (42.6 ± 3.4 g and 41.6 ± 5.2 g for control and deficit, respectively) than IL9-1 under both irrigation treatments (31.3 ± 2.7 g and 27.2 ± 3.1 g for the control and deficit treatments, respectively).

One aspect in which M82 did not outperform its ILs, however, was in proportion of unusable fruit and fruit quality (OBJ2c). M82's had more BER, rotten, and sunburned fruit, particularly under deficit irrigation. For example, BER for IL2-1 (1.37 ± 1.19% and 1.28 ± 0.70% for the control and deficit treatments, respectively) and IL9-1 (1.49 ± 0.69% and 0.73 ± 0.51% for the control and deficit treatments, respectively) were lower than in M82 (3.91 ± 0.94% and 5.66 ± 1.95% for the control and deficit treatments, respectively) under both treatments. Unexpectedly, IL-9's BER improved under the deficit treatment.

Some ILs also excelled in fruit sugar concentration (OBJ2c). While all the genotypes showed better Brix under the deficit treatment, all the ILs had a larger increase than M82, and IL5-4 (7.17 ± 0.21) and IL9-1 (6.85 ± 0.25) had greater Brix than M82 (5.89 ± 0.49). Fruit pH was slightly more acidic in IL5-4 (4.38 ± 0.02) than

M82 (4.42 ± 0.03) in the deficit treatment. Color was more desirable in IL5-4 (25.65 ± 0.24 and 25.58 ± 0.16 for the control and deficit irrigations, respectively) than M82 under both irrigation regimes (24.8 ±0.18 and 24.74 ± 0.08 for the control and deficit irrigations, respectively), and for IL2-1 (25.62 ± 0.11) than M82 in the deficit treatment. Thus, fruit characteristics suited for deficit irrigation are especially interesting in IL5-4 (high Brix, low pH, and good color) and in IL9-1 (high Brix and low BER incidence) despite its small fruit size.

Fewer significant differences were observed between the other two background tomato genotypes and their ILs, or amongst the high yielding cultivars (OBJ2c). Most interesting was the improved fruit quality in the Sucrose IL under the deficit treatment compared to Hunt 100. Brix (8.54 ± 0.23), pH (4.57 ± 0.04), and color (25.77 ± 0.29) tended to be higher in the Sucrose IL's fruit than in Hunt 100 (7.2 ± 0.34, 4.65 ± 0.02, and 24.54 ± 0.26 for Brix, pH, and color, respectively), although differences were not always significant. In the control treatment, the Sucrose IL's fruit were smaller (33.06 ± 2.08 g) than Hunt 100 (44.5 ± 3.14 g), while the fruit %-dry matter was higher (7.64 ± 0.73 and 6.12 ± 0.53% for the Sucrose IL and Hunt 100, respectively), but these differences did not occur in the deficit treatment. Thus the results of this severe water deficit trial has provided some important options for traits to better deal with water stress, mainly with respect to improving fruit quality and fruit disorders, which were of strong interest to the industry (OBJ2c).

<u>H.M. Clause Seed Company 2014 field experiment: full irrigation control vs. terminal season 20% of control deficit irrigation treatment (OBJ2d)</u>

Based on the data from the 2013 trial and discussions with U.C. researchers, H.M. Clause Seed Company indicated interest in further collaboration by providing field trial space and management for the 2014 trial (OBJ2d). The researchers, with consultation with their plant breeders, selected four genotypes. These genotypes had the highest variation in phenotype compared to their background cultivars (e.g., canopy size, height, shoot biomass, number of inflorescences, photosynthesis, fruit sugar content, and leaf size) and so were tested for coupling of cultivar traits for higher productivity under low water availability (OBJ2d).

In 2014, the terminal deficit treatment (80% reduction of the full season control) began during fruit set, about half way through the season (OBJ2d). Not only was this a different approach to water deficit than in 2013, but more irrigation was applied to both treatments, partly due to the lack of soil recharge during the previous winter, and to coarser soil texture than the 2013 field. A more severe deficit was imposed than anticipated in the originally approved project proposal (OBJ2d), due to heightened interest in drought as many growers are faced with decreasing their planting acreage as a result of the current drought and very uncertain water allocations. Lack of field space prevented adding planting density as a treatment as originally planned, but to compensate, much higher effort was put into the physiological and fruit quality measurements (OBJ2d).

Yields were greater for all genotypes under both 2014 irrigation treatments than in 2013, except for IL2-1 (OBJ2d). The growth reduction under terminal drought was 20 to 30 percent of the full season treatment. As in 2013, IL5-4 (0.37 ± 0.02 kg and 0.38 ± 0.11 kg under the control and deficit, respectively) and IL9-1 (0.35 ± 0.10 and 0.33 ± 0.05 kg for the control and deficit irrigations, respectively) had greater shoot biomass than M82 (0.18 ± 0.01 and 0.18 ± 0.02 kg for the control and deficit irrigations, respectively) (OBJ2d). But as before, no differences occurred in yields compared to M82, despite a trend for these IL5-4 (100.18 ± 2.87 tons ha^{-1} and 76.11 ± 3.67 tons ha^{-1} for the control and deficit treatments, respectively) and IL9-1 (109.59 ± 10.24 tons ha-1 and 73.34 ± 2.82 tons ha^{-1} for the control and deficit treatments, respectively) to have yields 10 to 20 percent higher than M82 (89.21 ± 10.07 tons ha^{-1} and 72.33 ± 2.73 tons ha^{-1} for the control and deficit treatments, respectively). WUEc was similar across all the genotypes except for the unusually small IL2-1.

Again, M82's fruit size (55.5 ± 6.1 and 52.2 ± 2.2 g for the control and deficit treatment, respectively) was larger than IL9-1 (36.4 ± 2.0 and 36.1 ± 5.0 for the control and deficit treatments, respectively) in both treatments, but also larger than IL2-1 (39.1 ± 7.1 and 35.2 ± 2.6 for the control and deficit treatments, respectively). As before, fruit size was similar between M82 and IL5-4 under both treatments (OBJ2d).

M82's ILs again outperformed M82 in several fruit quality measures (OBJ2d). Brix was lower in M82 (3.9 ± 0.06 and 4.38 ± 0.21 for the control and deficit, respectively) than all of the ILs under both the control (4.49 ± 0.19, 4.38 ± 0.14, and 4.72 ± 0.16 for IL2-1, IL5-4, and IL9-1, respectively, under the control treatment) and the deficit irrigations (4.82 ± 0.17, 5.22 ± 0.06, and 5.53 ± 0.12 for IL2-1, IL5-4, and IL9-1, respectively, under the deficit treatment). M82 also tended to have higher pH (4.4 ± 0.03 for both control and deficit treatments) than any of the ILs under the control (4.39 ± 0.03, 4.35 ± 0.03, and 4.25 ± 0.03 for IL2-1, IL5-4, and IL9-1, respectively) and deficit (4.36 ± 0.03, 4.29 ± 0.02, and 4.12 ± 0.02 for IL2-1, IL5-4, and IL9-1, respectively) treatments. Titratable acidity was markedly lower in IL5-4 (9.32 g^{-1}) than M82 (21.82 ± 5.42 g^{-1}) under deficit irrigation, but no other differences occurred. M82 had lower fruit viscosity (28.53 ± 1.78 cm^{-1}) than any of the ILs except IL5-4 (29.57 ± 6.39 cm^{-1}) under full irrigation, as indicated by its higher Bostwick fruit paste consistency test (OBJ2d).

More unusable fruit again occurred in M82 compared to its ILs (OBJ2d). M82 had higher BER (6.09 ± 2.75% and 4.22 ± 1.82% for the control and deficit treatment, respectively) than any of the ILs in both the control (0.75 ± 0.01, 0.48 ± 0.01, and 0.09 ± 0.19% for IL2-1, IL5-4, and IL9-1, respectively) and deficit (1.27 ± 1.71, 1.28 ± 0.56, and 0.68 ± 0.24% for IL2-1, IL5-4, and IL9-1, respectively) treatments. IL5-4 (1.50 ± 1.00%) had less rotten fruit than M82 under deficit irrigation (6.13 ± 1.58%). Only IL2-1 had more rotten fruit than M82, but only in the deficit treatment (10.76 ± 2.90%). Little sunburned fruit occurred in 2014 (OBJ2d).

<u>Conclusions on deficit irrigation effects on procession tomato genotypes (OBJ2a, OBJ2c, OBJ2d)</u>
The cultivar M82 has been widely used in hot, water-limited processing tomato production systems and was produced through extensive breeding efforts many years ago (OBJ2a). Yield of this cultivar was similar or higher to its ILs lines in the very different water environments experienced in the 2013 and 2014 trials (OBJ2c and 2d). The reason for higher yields in 2014 is likely due to the greater water applied for both the control and deficit treatments, but also due to the full supply of irrigation during plant development, flowering, pollination, and early fruit set. The shorter growing season and small size of M82 allow for a higher HI, and potentially a greater allocation of resources to the fruit instead of canopy and root maintenance and development. The small size of the background cultivar combined with high yield allowed for a much higher WUEc than for M82's ILs, particularly under the full season deficit (OBJ2d).

Fruit quality characteristics of M82's ILs, however, were more desirable than for M82 (OBJ2c and 2d). Fruit quality measures such as Brix, fruit pH, paste consistency, and color were lower in M82 than its ILs. For systems under severe deficit irrigation (as in the 2013 trial), fruit characteristics of IL5-4 (high Brix, low pH, and good color) and in IL9-1 (high Brix and low BER incidence) despite its small fruit size, will be of interest to plant breeders. For systems under milder terminal drought (as in the 2014 trial), M82's ILs have desirable traits that contribute to higher Brix, lower fruit pH, and higher fruit viscosity. In addition, the ILs provide a source of plant material that is less susceptible to the fruit disorder, BER, and to other factors that cause rotting fruit (OBJ2a, OBJ2c, and OBJ2d).

Crop modeling and spatial analysis (deviation from planned OBJ2e and OBJ2f)
The United Nations Food and Agriculture AquaCrop model turned out to be too coarse to use for the very detailed physiological data sets collected in the H.M. Clause Seed Company experiments, which ended up focusing on new germplasm rather than existing cultivars, due to widespread concern about adapting to major drought (Obj2e). The researchers and Geographic Information System (GIS) Specialist produced a site-specific GIS of the 2013 dataset to examine the spatial heterogeneity of the tomato field, generating a useful approach for spatial analysis to fine tune management + cultivar options for coping with low water availability (OBJ2f). The GIS database based on soil types, crop management, water sources and climate data was abandoned because the fine-scale study on crop traits was not suited to such large scale databases.

Dissemination of results (OBJ3a, OBJ3b, OBJ3c, and OBJ3d)
The experimental results and conclusions have been shared with 50 growers, 15 plant breeders, the breeders of the H.M. Clause Seed Company, and four farm advisors (OBJ2a). No formal field day was conducted, but >25 people visited the trial to discuss tradeoffs and management (OBJ3b). Reports are complete, a webpage exists on the project, and a scientific publication will be submitted within the year (OBJ3c). Cooperator meetings were held frequently, from once a week to every three months, depending on the issues and decisions at hand (OBJ3d).

This project only benefited processing tomatoes.

H.M. Clause Seed Company provided the land and managed the trials for both the 2013 and 2014 experiments and their expertise proved to be invaluable in ensuring the treatments were carefully implemented. They also conducted the fruit quality analyses using industry standard approaches. The development of the collaboration with the seed company reduced costs and created a direct conduit to the end-users of the data. All data are available to any member of the public by request or in the forthcoming scientific publication.

Goals and Outcomes Achieved

The following are the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments:

(Outcome 1) The survey will show: a) tomato growers' concerns for adaptation to lower water availability; and b) growers' input on cultivars and traits for better crop performance under low water availability: The grower surveys indicated a general interest in production cultivars that possess extended field storage (EFS) or extended field holding (EFH) when queried about which types of tomatoes they would grow for water-limited years. Growers demonstrated a strong interest in research in how a number of different morphological and physiological traits might affect tomato production under limited water. The most commonly cited traits included those related to minimizing BER (i.e. blossom end rot which is a common problem under water stress), and better resistance to heat during early growth and, in particular, fruit set. The potential value of traits that confer chilling tolerance in the expectation that early planting could avoid the times of greatest water stress during crop development were also of grower interest. A number of growers also suggested that they would consider altering their tomato management if research showed that the incorporation of genetic information from wild species to improve crop performance under limited water produced viable results. The researchers incorporated their suggestions for production cultivars to include in the trial, and sought out and found experimental introgression lines that were thought to convey many of the potential benefits in which the growers were most interested.

(Outcome 2) Identify at least three traits in modern processing tomato cultivars to adapt to lower water availability by increasing crop WUE without a yield decrease: In the 2014 terminal drought experiment, two of the experimental genotypes of processing tomato, IL9-1 and IL5-4, had yields that were very similar to the background baseline genotype M82. (M82 is an older variety that has long been grown in arid regions with low water availability). These two genotypes had much improved Brix and lower rates of the BER disorder than the background M82 genotype under both the full and terminal deficit irrigation treatments. Other traits for which IL5-4 and IL9-1 outperformed M82, and thus might represent good potential breeding traits, include a larger canopy, more nitrogen in the leaf, and higher levels of leaf photosynthesis and transpiration. They also had greater sap flow rates (a measure of water transport from roots to shoots) that may indicate a larger root system. Inclusion of the genetic material from these genotypes into processing tomato production could result in better yields, and potentially higher fruit quality across a range of water availabilities

(Outcome 3) Identify at least two management practices that along with specific cultivar traits (Outcome 2) can secure a reliable yield in dry years: Using a terminal deficit irrigation management approach in the 2014 field season (i.e., cut irrigation severely during the last half of the season, but apply full water amounts prior to that) showed promise in terms of decreasing the yield loss as a result of a water shortage (recall that the 2013 field season took a continuous water deficit approach throughout the entire growing season). The greater amount of water applied during the early part of the 2014 season, particularly during plant development and fruit set, increased yields substantially for the genotypes when contrasted to the results of a full season deficit trial (i.e., the 2013 field season). Shoot biomass and canopy cover were larger in the 2014 trial as well, regardless of irrigation treatment, suggesting that the terminal drought strategy may be an effective way to 'hedge bets' early in the season, to deal with the uncertainty of availability of late season water. Better yields in the 2014 season as compared to the 2013 season, however, were associated with a general decrease in some fruit quality parameters, such as Brix.

(Outcome 4) Make available a calibrated Aqua crop model and a Geographic Information System (GIS) database for California conditions using field data on cultivar responses to lower water availability to ground truth outcomes: The researchers and GIS specialist produced a site-specific GIS of the 2013 dataset to examine the spatial heterogeneity of the tomato field. The incorporation of the GIS database and the data generated in this study into the AquaCrop model was planned. The AquaCrop model uses simple data sets on water inputs and soils to simulate biomass and yield responses. It is a general agronomic model developed by the United Nations Food and Agriculture Organization. However, this outcome was not fully completed as the researchers realized that it is not useful or relevant to this project for two main reasons. First, the 2013 and 2014 field experiments were run in collaboration with the H.M. Clause Seed Company, rather than on grower fields, and fortunately, this meant that the experiment was conducted with very detailed accuracy but a small scale too fine to be useful in the AquaCrop model. So the range of irrigation and soil data is not sufficient to calibrate and run the model. Second, the emphasis on detailed traits of a few unique experimental genotypes is already proving to be very interesting to tomato breeders, and to industry members thinking ahead to the future likelihood of drought in the State, which will require new genotypes attuned to specific deficit irrigation strategies. This is a more important result than a model showing how water inputs will impact yield of current varieties.

(Outcome 5) Increase awareness of tomato growers, plant breeders, farm advisors and non-governmental organizations (NGOs) to facilitate the search for specific traits to couple with management practices in dry years, and thus assist in adapting to climate change: Results of the research were presented at an outreach meeting in both February and December of 2014 with H.M. Clause Seed Company plant breeders and researchers, and at an extension grower meeting at the West Side Research & Extension Center, at Five Points, CA in March of 2015. The discussions with H.M. Clause Seed Company plant breeders and other representatives resulted in high levels of interest in looking at ways to introduce more water efficient traits into new processing tomato variety development. Meetings with farm advisors who work on processing tomatoes were very productive in terms of understanding the data from the two field seasons, and they will also serve as conduits for information dissemination.

The outreach efforts are ongoing (see Outcome 5 summary above). A scientific peer-reviewed publication is currently undergoing revision for submission to a journal, it will be submitted by April 2016.

The following is a comparison of actual accomplishments with established project goals:

Objective 1: Survey tomato growers' water concerns for responses to climate change
Grower surveys were conducted online (via Surveymonkey) as well as through paper forms handed out at grower meetings. The surveys indicated a general interest in researching ways to breed better performance under low water availability particularly in regards to less susceptibility to heat stress during fruit set, and the incidence of BER (blossom end rot). Both of these problems will likely be exacerbated under climate change. The grower surveys indicated a general interest in production cultivars that possess extended field storage (EFS) or extended field holding (EFH) when queried about which types of tomatoes they would grow for water-limited years. The researchers incorporated their suggestions for production cultivars to include in the trial, and sought out and found experimental introgression lines that were thought to convey many of the potential benefits in which the growers were most interested.

Objective 2: Identify plant traits and compatible management
The strong collaboration with H.M. Clause Seed Company provided the opportunity to expand the scope of this objective well beyond what was originally included in the grant. More measurements took place over a wider range of time and a greater number of physiological and morphological traits were collected over the 2013 and 2014 field seasons than anticipated. Extensive discussion of results and field work with breeders at H.M. Clause Seed Company resulted in very high levels of interest in the research and initial talks about what traits to look in to for breeding purposes. For example, different traits such as larger plant size, higher leaf gas exchange for photosynthesis and transpiration, and greater sap flow rates may be associated with better yields under low water availability, but fruit quality traits are important as well.

Objective 3: Conduct outreach for awareness of the results of Objectives 1 and 2
Results of the research were presented at an outreach meeting in both February and December of 2014 with H.M. Clause Seed Company plant breeders and researchers, and at an UC Cooperative Extension grower meeting at the West Side Research & Extension Center, at Five Points, CA in March of 2015. Discussions with plant breeders, seed company representatives, farm advisors, and interested growers will continue over the next year, while an article continues to be developed for publication. Information dissemination will continue when the final documents and published article are complete.

Please see the summaries of the two experiments above under project approach regarding completion of achieving outcomes.

The major successful outcomes of the project are as follows:

- Traits exist in wild species of tomatoes that can be bred into production hybrids to increase fruit quality aspects including sugar levels (Brix), lower pH, and resistance to blossom end rot under both adequate and low water availability.
- Management of the timing of deficit irrigation can impact fruit quality and yield. Decreasing applied water after plant development and early fruit set results in greater yields than a full season deficit irrigation approach.
- Yields decreased by 20-30% under the severe deficit treatments relative to the control treatment regardless of when the deficit was started.

Beneficiaries

The processing tomato industry will benefit from results of this research, particularly as this drought continues, or new drought periods occur. Direct benefits will also go to farmers, seed companies, and ultimately, tomato processors. In total, given the size of the industry and its California acreage of more than 250,000 acres, at least 50 farmers and three seed companies can directly use the project information now. Additional farmers (perhaps 25) will benefit from the research to develop drought coping strategies, and if the tomato genotypes are used in breeding, then another three seed companies and five tomato processor operations would benefit. Plants with traits adapted to drought, along with irrigation management options, can help growers continue to produce processing tomatoes and avoid fallowing as much land if the drought continues in California. Seed companies will be able to use the knowledge gained through the study of the experimental ILs to broaden breeding programs to include traits from wild species to allow for better production under low water availability. The detailed information on genotypes and traits will be widely available from the scientific article that will be published within the next year. If possible, an open-access journal will be used so that anyone can access the publication free of charge.

Outreach efforts by the PD, PI, and GS directly shared the experimental results and conclusions with 50 growers, 15 plant breeders, the R&D team of the H.M. Clause Seed Company, and four farm advisors. The PD and the PI have produced a webpage that discusses the experimental results to increase outreach impacts: (http://ucanr.edu/sites/Jackson_Lab/Roots_and_Mycorrhizae_857/Cultivar_traits_to_improve_tomato_water_use_efficiency_and_yield_under_low_water_availability/).

Further outreach by the research team, farm advisors, and other stakeholders will expand the numbers of growers and breeders informed by this research.

Lessons Learned

Setting up the experiment to address two different deficit irrigation management approaches allowed the researchers to look at trends in crop performance across a range of unique experimental genotypes that had different collections of physiological and morphological traits. While performance differed between the two field seasons, trends persisted across both years. The ILs consistently had better fruit quality aspects, but yields were typically similar or than the background cultivar, M82.

The collaboration with H.M. Clause Seed Company was extremely beneficial and fruitful. The company supplied land and all management inputs, actively participated in the research, and followed the experimental outcomes with great interest. In particular, the high crop water use efficiency observed in both 2013 and 2014 created interest within the company on a national and international level for tomato breeding under low water availability. Incorporating the fruit quality traits of wild species of tomatoes into production genotypes was also of interest to the personnel at H.M. Clause Seed Company. Without this close collaboration, it would have been much more difficult to extend the results of the research to industry tomato breeders.

Working with H.M. Clause in large trials with precise management allowed the researchers to do extensive fine-scale plant physiology work that allowed for a much deeper investigation into the interaction of deficit irrigation and important agronomic and physiological traits across a range of genotypes than was originally envisioned. However, this fine scale work was not translatable to the coarse-scale AquaCrop model, which is pertinent to comparing cultivars under broad differences in soil types, and emphasizing agronomic rather than physiological information. The researchers felt the tradeoff was a good one, as the more focused work provided important insights that would have been missed otherwise, and generated substantial interest from industry tomato breeders.

Additional Information

The details of materials and methods used on the project can be found in the attachment. Additional information is available upon request.

http://ucanr.edu/sites/Jackson_Lab/Roots_and_Mycorrhizae_857/Cultivar_traits_to_improve_tomato_water_use_efficiency_and_yield_under_low_water_availability/

USDA Project No.: 40	**Project Title:** Sustainable Technologies for Olive Mill Wastewater Management	
Grant Recipient: Robert Mondavi Institute for Wine and Food Science	**Grant Agreement No.:** SCB12040	**Date Submitted:** December 2015
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Project Summary

The California olive oil industry produces more than 600 million gallons of wastewater each year and this number continues to climb every year with increased planting and production. Olive mill wastewater (OMWW) is considered a highly polluting effluent due to its high organic load and resistance to biological degradation. A current trend in OMWW management is to not only decrease environmental pollution but also extract and utilize valuable by-products. The objectives of this study were to develop an energy-efficient separation technology for OMWW treatment, to extract health-promoting phenolic compounds, and to explore possibilities of phenolic compounds utilization.

More oil and more wastewater is being produced in California every year, the disposal of the wastewater is the number one concern for all of the large producers. While it's a common knowledge that there is economic value in the utilization of OMWW, there is not a developed technology that can be adopted easily by the industry.

The project did not build on a previously funded Specialty Crop Block Grant Project.

Project Approach

In November 2012, approximately 30 gallons of olive mill wastewater (OMWW) were collected from each of three California mills. Chemical and nutritional properties of the raw OMWW were characterized by chromatographic and spectroscopic methods and chemical (total soluble phenolics and antioxidant capacity) analysis. Physical analyses (including water, oil, and solids ratio of waste water, moisture content and particle size of dried solids, and color and clarity of water after separation) were determined using standard methods. All measurements have been recorded in a laboratory notebook dedicated to this project. University of California, Davis (UC Davis) Olive Center and United States Department of Agriculture – Agricultural Research Service (USDA-ARS) personnel both participated in the collection of the OMWW. USDA-ARS personnel conducted the chemical, nutritional, and physical analyses of the raw OMWW.

Additional methods were explored of determining the extent of solid/water separation beyond spectrophotometry. Initial findings indicated that turbidity and chemical oxygen demand may be better indicators of separation than spectrophotometry.

UC Davis Olive Center worked with New Logic Research (in-kind) to set up the filtration system at UC Davis Food Processing Pilot plant. The training, provided by New Logic, was completed. A graduate student started the trial phase of this study on separation and purification of olive pomace/water with membrane filtration system. Several membranes have been tested and their performances have been evaluated by chemical analysis.

The UC Davis Olive Center Principal Investigator (PI) was contacted by many industry leaders who showed a lot of interest in this study. Project staff shared the scope of this study, however, it was explained that sufficient data to summarize the outcome of this study has yet to be collected.

In early 2013, the project post-doc conducted laboratory-scale separation experiments to determine the effects of centrifugation processing parameters on a suite of quality metrics (turbidity, suspended solids content, chemical oxygen demand, etc.). OMWW from three California olive mills was included in these analyses. One of these mills uses the "2-phase" process; the primary output streams from a 2-phase mill are olive oil and a wet, heavy, sludge-like material (called "pomace") that contains the olive flesh and pits. In a 2-phase mill, OMWW is produced as a third, minor output stream. In contrast, the other two mills participating in the study use the "3-phase" process. In the 3-phase process, there are three major output streams: olive oil, a dry pomace, and OMWW. A significant finding from the laboratory-scale separation experiments was that separation efficiency varies strongly according to which type of OMWW – 2-phase or 3-phase – is centrifuged. Thus, different best practices will have to be developed for these different incoming material streams.

USDA-ARS staff and the project post-doc began method development for analysis of the OMWW's component chemicals via the technique of High Performance Liquid Chromatography (HPLC). HPLC is a widely-used chromatographic technique, but the conditions for sample preparation and operation of the instrument will be different for each type of sample. Project team members conducted a literature search on the topic and began testing out different HPLC configurations to determine which would work best for OMWW. Success was had with the HPLC analysis that was conducted on Agilent Technologies 1290 model with UV-DAD detector with a reversed-phase C18 column (2.1*100mm, 2.7 µm). Five standard phenolic compounds were selected to identify the interested compounds in the samples, and to later on quantify them. These compounds are: tyrosol, hydroxytyrosol, caffeic acid, gallic acid, and p-coumaric acid. Standard solutions of following concentration: 0.01, 0.05, 0.10, 0.15, 0.25, 0.5 g/L, were made with 50/50 DI water/methanol solvent. As the peaks were identified in chromatographs, standard curves of each compound were determined.

In June 2013, USDA-ARS and UC Davis staff made a site visit to a partnering olive mill where they summarized the initial data from the OMWW that had been collected from that site in November 2012. (This mill was the one 2-phase mill included in the study.) The project staff informed the mill staff about the values of the quality metrics (turbidity, suspended solids content, chemical oxygen demand, etc.) measured for that mill's OMWW. The project staff also summarized the initial findings for separation of the mill's OMWW using centrifugation and membrane filtration. The mill staff noted these results and offered suggestions for additional measurements that could be taken of the OMWW during future collections.

UC Davis staff finished the separation and purification of olive pomace/water with membrane filtration system. Optimum membrane conditions have been identified; efficiency of the filtration system performance was evaluated by chemical analysis. Project staff found the most effective processing was as follows: For the first step filtration, PES-5/Tyvek membrane with 7000 Dalton pore size was applied to the samples to remove most of particles in the waste water. Energy-Saving Polyamide (ESPA) membrane with 40 Dalton pore size was later applied to permeate (solution rich in polyphenols) of PES-5 filtration, to further concentrate the phenol-rich solution. Samples for analysis were collected at following points: 1) PES-5 initial feed at 0min of concentration; 2) PES-5 permeate at 0min of concentration; 3) PES-5 final concentrate when the concentrating step is finished; 4) ESPA initial feed sample, which practically is the same as PES-5 permeate at 0min of concentration, was taken at 0min of ESPA concentration to eliminate the change due to storage condition; 5) ESPA permeate at 0min of concentration; and 6) ESPA final concentrate when the concentrating step is finished. From the chemical HPLC analysis, it was found that the quality of ESPA permeate (sample 5) is comparable to drinking water in some aspects (e.g., conductivity, %Solids). The project team was encouraged by this finding, and currently working on identifying the best separation method for the polyphenols in OMWW.

By November 6th, 2013, USDA-ARS and UC Davis staff completed the collection of olive pomace/water samples for 2013 harvest. Approximately 40 gallons of (OMWW were collected from the same California as in November 2012. The collection went well and all the samples were properly stored for chemical and physical analysis. USDA-ARS and UC Davis staff looked forward to performing the same treatment to this year's olive pomace/water samples to see how different the olive pomace/water were from last year to this year.

In October 2013, USDA-ARS staff conducted additional centrifugation experiments to test separation efficiency of a laboratory centrifuge in olive mill wastewater (OMWW) treatment. The objectives of this study were to evaluate efficiency of centrifugation and identify optimum centrifugation time and speed for 2-phase and 3-phase OMWW using industrially-feasible conditions. Optimum removal efficiency for all tested parameters was centrifugation speed/time of 5,500 rpm (3,382 x g)/55 min for 2-phase OMWW, and 5,500 rpm (3,382 x g)/33 min for 3-phase OMWW. The removal efficiencies of the centrifugation process, especially in terms of suspended solids, turbidity, and chemical oxygen demand, indicate that centrifugation can be utilized in OMWW management. Furthermore, initial centrifugation could improve the efficiency of subsequent separation processes, such as membrane filtration.

In October and November 2013, USDA-ARS and UC Davis staff completed the collection of olive pomace/water samples for 2013 season. Approximately 40 gallons of OMWW were collected from each of the same California mills as in November 2012. The collection went well and all the samples were properly stored (frozen and freeze-dried) for further chemical and physical analyses. USDA-ARS staff performed the same treatment to 2013 year's fresh olive pomace/water samples to see how different the olive pomace/water was from 2012 season to 2013 season. The list of conducted analyses was expanded with the new methods (total, dissolved and suspended solids, and chemical oxygen demand) which were developed during spring 2013.

Progress on development of HPLC method for phenolics from OMWW includes the following chromatographic conditions and extraction procedure: HPLC system used was Hewlett-Packard 1100 equipped with manual injector, quaternary pump, thermostatted column compartment, 1100 diode array detector, and Phenomenex Luna Column C18(2) (250x4.6 mm, 5µm). Solvents were 1% acetic acid in water (A) and methanol (B), with the gradient: 10% B 0min, 30% B 20min, 30% B 5 min, 40% B 10min, 50% B 15min, and 100%B 10 min. HPLC conditions were as follows: flow rate: 0.8 mL/min, detection wavelength

254 and 280 nm, injection volume: 5 µL. Extraction of phenolic compounds was carried out on freeze-dried OMWW samples washed with hexane, and extracted with MeOH/H2O (80:20). Evaporated extract was dissolved, and solid-phase extraction on C18 was performed. Thirteen standards of phenolic compounds (gallic acid, 3-hydroxytyrosol, tyrosol, 4-hydroxybenzoic acid, chlorogenic acid, 4-hydroxyphenyl acetic acid, vanillic acid, caffeic acid, p-coumaric acid, ferulic acid, verbascoside, rutin, and oleuropein) were selected to identify the compounds of interest in the samples, and to later on quantify them.

In January 2014, to disseminate project results, USDA-ARS staff submitted a scientific paper abstract entitled "Centrifugation as a Pre-treatment in Olive Mill Wastewater Processing" to the Institute of Food Technologists Annual Meeting & Food Expo in New Orleans, Louisiana. The target audience was food scientists with a special interest in food byproduct and there were about 50 people who engaged conversations about this project. The paper's highlights included optimization of centrifugation process (time and speed) in order to achieve maximum removal efficiencies of the tested parameters (total, dissolved, and suspended solids, turbidity, and chemical oxygen demand). The paper was accepted for a poster presentation. (See Attachment 1)

The project post-doc attended two-day workshop on Batch/Bio-Process Modeling and Production Scheduling in San Jose, California on January 16-17, 2014. This training was organized by the Intelligen, Inc., and included theory and hands-on sessions with SuperPro Designer – a comprehensive process simulation program that facilitates modeling and optimization of batch and continuous processes, cost of goods analysis, cycle time reduction, and environmental impact assessment. The purpose of the training attendance was future use of the SuperPro Designer software tool in modeling the economic and environmental impact of each separation technology.

In April 2014, the samples of sequential membrane filtration stream retained after passing ESPA reverse osmosis (RO) (40 Dalton filter pore size) filter (ESPA concentrate) from 2012 season OMWW were picked up from UC Davis. The project post-doc conducted the preliminary experiments to characterize the ESPA concentrates from each mill. Furthermore, drying of ESPA concentrate was tested by spray drying, freeze drying, infrared drying, and microwave drying. The objectives of this study were to explore drying possibilities of ESPA concentrate, and to establish the drying conditions for each of the drying techniques. The results of this experiment showed that drying of ESPA concentrate is not possible without addition of some kind of carrier, due to the low solids content. Addition of 5-10% maltodextrin as a carrier was applied. From above-mentioned drying techniques, only microwave drying was not successful in obtaining dried material. Concentrated material from membrane filtration was not collected in a way that was conducive to further drying (not enough sample amounts, storage conditions); thus results obtained from these experiments were only exploratory.

In May 2014, the project graduate student presented the poster "Membrane Filtration for Enrichment of Phenolic Compounds in Olive Mill Wastewater" at the American Oil Chemists' Society Annual Meeting in San Antonio, Texas. The target audience was oil chemists with a special interest in food byproduct and there were about 40 people who engaged conversations about this project. The paper's highlights included optimization of membrane filtration process and characterization of the phenolic compounds.
(See Attachment 2)

In June 2014, USDA-ARS and UC Davis staff met at the USDA-ARS facility in Albany, California to discuss progress on the project and establish work plans for the following months. Based on the summary of published data on usage of commercial and alternative resins, and on their potential industrial use in OMWW treatment, as well as their feasibility, it was decided not to run lab-scale separation experiments with resins.

On June 23, 2014, the project post-doc presented the paper "Centrifugation as a Pre-treatment in Olive Mill Wastewater Processing" at the Institute of Food Technologists Annual Meeting & Food Expo, in New Orleans, LA. The poster was exhibited within the "Food Engineering Division: Sustainability" poster session. Approximately one dozen specialty crop industry stakeholders viewed the results in this presentation.

In July 2014, the thawed OMWW samples from 2013 season (15 gallons from each mill) were delivered to the Olive Center for membrane filtration process.

After the OMWW from 2013 season was subjected to a sequential membrane filtration process, feed, permeate, and concentrate streams were characterized by physical, chemical, and spectroscopic analysis methods.

During the summer of 2014 freeze-dried OMWW samples were analyzed by High Performance Liquid Chromatography – Diode Array Detection (HPLC-DAD). The freeze-dried OMWW samples were found to contain *p*-coumaric acid in concentrations ranging from 0.13 ± 0.02 mg/g freeze-dried OMWW to 0.17 ± 0.01 mg/g freeze-dried OMWW. Luteolin was only identified in one of the OMWW samples in a concentration of 0.37 ± 0.04 mg/g freeze-dried OMWW.

In September 2014, the USDA-ARS staff planned a response surface experiment for spray drying of ESPA concentrate to establish the spray drier inlet temperature/pump speed combinations necessary to obtained dried powder with maximum phenolics content and minimal energy consumption.

In October 2014, the collection of olive pomace/water samples for 2014 season was accomplished. Approximately 35 gallons of olive mill wastewater (OMWW) were collected from each of the same California mills as in November 2013. The collection went well and all the samples were properly stored (frozen and freeze-dried) for further chemical and physical analyses. USDA-ARS staff performed the same treatment to 2013 year's fresh olive pomace/water samples to see how different the olive pomace/water was from 2012 season to 2013 season. The samples were analyzed for chemical and physical properties within 24 hours of the collection.

In November and December 2014, the project post-doc explored different techniques (spray drying, freeze drying and infrared drying) for drying a phenolic-rich membrane filtration fraction of OMWW (ESPA concentrate) from 2013 season and compared the techniques in terms of the dried product quality and feasibility of the process. ESPA samples from all three mills with addition of 10% maltodextrin were dried by spray drying, freeze drying and infrared drying. Dried ESPA concentrates were tested for the process recovery, water activity, moisture content, color properties, total soluble phenolics and antioxidant capacity.

In December 2014, results from the ESPA concentrate drying experiments of were analyzed, and the abstract entitled "Olive Mill Wastewater Membrane Filtration Fraction: Drying Techniques and Quality Assessment of the Dried Product" was submitted to the Institute of Food Technologists Annual Meeting & Food Expo 2015, in Chicago, Illinois. The target audience was food scientists with a special interest in food byproduct and there were about 45 people who engaged in conversations about this project. The abstract was accepted for presentation in poster session: Sustainability. (See Attachment 3)

In February 2015, USDA-ARS staff completed the process flow model for the sequential membrane filtration of the OMWW. This model, constructed in the software SuperPro Designer, predicts the separation efficiency of both the overall process and the individual separation operations. USDA-ARS staff also performed evaporation/concentration of the OMWW from one of the mills to test out this technique as a possible pretreatment before separation techniques are applied. Also in February 2015, the project post-doc worked on a response surface experiment for spray drying of ESPA concentrate to establish the optimum spray drier inlet temperature/feed pump combinations. For each of the nine temperature/feed pump combinations, for a total of 11 spray drying trials (triplicates for central point) energy consumption measurements were recorded. Finding the optimum responses in an response surface experiment was achieved by setting the desired goals for each of the explanatory variables (process recovery, total soluble phenolics, and antioxidant capacity were set to be maximized; energy consumption and moisture content were set to be minimized).

In March 2015 the frozen OMWW samples from 2014 season (10 gallons from each mill) were delivered from Albany to the Olive Center for membrane filtration process. The project post-doc submitted the abstract entitled "Sustainable Technologies for Olive Mill Wastewater Management" to the Postdoctoral Research Symposium - UC Davis. The target audience was post-doctoral scholars from various fields and there were about 10 people who engaged in conversations about this project. (See Attachment 4)

In April 2015, the samples of sequential membrane filtration from 2014 season OMWW were picked up from Olive Center for analyses. OMWW membrane filtration fractions samples from 2014 season (feed, permeate, and retentate streams) from all three mills were tested at USDA-ARS laboratory for the chemical and physical properties. The obtained results were compared to the results from 2013 season.

On May 4, 2015 the UC Davis Olive Center executive director gave an oral presentation "Sustainable Technologies for Olive Mill Wastewater Management" at the American Oil Chemists' Society Annual Meeting in Orlando, Fl. The target audience was oil chemists, olive oil processors from many different countries and there were about 60 people who engaged in conversations about this project.

On May 14, 2015 the project post-doc presented the poster "Sustainable Technologies for Olive Mill Wastewater Management" to the Postdoctoral Research Symposium - University of California, Davis.

On May 22, 2015 the project PI and the project post-doc presented the project results to the Olive Oil Commission of California. The presentation was held at Olive Center as a part of a regular Commission's meeting. The target audience was olive growers, olive oil processors and industry leaders and stake holders. There were about 20 people in attendance.

In May 2015, the evaluation of economic costs of both sequential membrane filtration and drying techniques started with the project agricultural economist who was a contractor on this project. The economist spoke with all the experts in this area and visited the largest California olive oil producer, to collect information first-hand from the producers. He also connected with a supplement company to get information on the value of dried product developed from this project. A peer-reviewed journal manuscript/stakeholder-focused report/trade magazine article based on the economic analysis will be submitted for publication in January 2016 (See Attachment 5).

In July 2015, the manuscript entitled "Membrane-Filtered Olive Mill Wastewater: Drying Techniques and Quality Assessment of the Dried Product" was submitted to the *Journal of Food Science*. (See Attachment 6) The main scope of the manuscript was to explore different techniques (spray drying, freeze drying and infrared drying) for drying a phenolic-rich membrane filtration fraction of OMWW (RO retentate) from 2013 season, and to compare the techniques in terms of the dried product quality and feasibility of the process. The project post-doc worked on a manuscript dealing with a response surface experiment for spray drying of RO retentate and establishing the optimum spray drier inlet temperature/feed pump combinations.

Goals and Outcomes Achieved

The primary goal of this project was to achieve a measurable reduction in the wastewater effluent streams from olive processing operations by at least 90%. During pilot-scale membrane filtration of the OMWW, the volumes of the various filtration fractions were measured. The membrane system vendor, New Logic, also estimated the flow rate of the effluent streams as part of their own analysis.

Stakeholder input, literature data, and regulatory information was used to determine which metrics would characterize the environmental toxic load of the OMWW. Five metrics were determined: total solids (TS), dissolved solids (DS), suspended solids (SS), turbidity, and chemical oxygen demand (COD). Baseline measurements of these metrics were taken for both 2-phase and 3-phase OMWW collected during the 2013 and 2014 harvest seasons, and the metrics were measured for the effluent streams from the centrifugation and membrane filtration experiments.

The UC Olive Center staff have been sharing the outcomes of this project with industry stakeholders and processors. The information has been shared with the Olive Oil Commission of California as well. Best Management Practices will be made available online in February 2016 at no cost to those who are interested in the technical and economical findings of this project. The team members have been and will continue to disseminate the results and assist olive processors to maximize water conservation, quality and byproduct value of olive oil byproducts.

The goals of this project were to develop integrated approaches to improve water quality, increase water conservation, decrease environmental damage and accelerate Best Management Practices for olive processing wastewater. All of these goals have been met. More details from the comparison with the baseline data are shown below.

Toward the outcome of reducing the wastewater effluent streams, pilot membrane filtration produced eight gallons of near-pure water for every 10 gallons of OMWW fed into the system – an 80% reduction. New Logic's analysis yielded a similar result: an 81% reduction in the volume of wastewater effluents. Although both of these results fall somewhat short of the original 90% reduction goal, the 80-81% reduction seems to be at the limit achievable by existing commercial equipment. Further reduction in the effluent streams could only be achieved through increasing energy input to the separation process and use of specialized equipment that is not typically used in the specialty crop food processing industry.

Toward the outcome of reducing environmental toxic load, it was found that centrifugation could reduce SS and turbidity by more than the 80% target but only reduced the other three environmental toxicity metrics by 20%. The sequential membrane filtration process that is the final recommendation from this project, however, was found to reduce all five metrics by at least 91% - well exceeding the target of 80% reduction. For example, the baseline Chemical Oxygen Demand (COD) of the 2014 OMWW was 12,555 mg/L and 122,463 mg/L for 2-phase and 3-phase samples, respectively. Using the sequential membrane filtration system, the output water stream had COD levels of 404 mg/L and 2,608 mg/L, representing reductions of 96% and 97% for 2-phase and 3-phase OMWW, respectively.

Toward the outcome of finding values in the byproducts, it was found the net cost of OMWW filtration relative to current (trucking) disposal is negative, meaning that OMWW filtration could save millers money. The estimate of this savings is approximately $0.04/gal OMWW. This does not include any values for the products. After doing research on market values for the phenol-rich retentates and contacted an American pharmaceutical company, it was concluded that there are very substantial potential economic values of the phenol-rich retentates, ranging from the hundreds to the thousands of dollars per day, can be gained by the processor. In addition, water values, associated with recovery and reuse of the water using in milling, are likely in the range of $10-$100/day.

The results of the OMWW filtration fraction drying experiment showed that drying of the Reverse Osmosis (RO) retentate is possible only with addition of 10% maltodextrin as a carrier, due to the low solids content. The highest recovery for both 2-phase and 3-phase RO retentates was achieved with freeze-drying. The total soluble phenolics in dried RO retentates were in the range 0.15 – 0.58 mg gallic acid equivalents/g of dry weight for 2-phase RO retentate, and 1.38 – 2.17 mg gallic acid equivalents/g of dry weight for the 3-phase RO retentates. Findings from this study show that drying of the membrane filtration stream of OMWW, especially spray drying, results in a powder which contains phenolics.

A complete identification and quantification of phenolic compounds present in dried RO retentate was accomplished. Phenolic compounds identified in dried RO retentate were: 3-hydroxytyrosol (52.3 – 108.1 µg/g dried RO retentate), tyrosol (4.53 – 138.7 µg/g dried RO retentate), vanillic acid (2.80 – 105.3 µg/g dried RO retentate), and p-coumaric acid (1.13 – 24.5 µg/g dried RO retentate). Tyrosol, vanillic acid, and p-coumaric acid were quantified in both 2- and 3-phase dried RO retentate, whereas 3-hydroxytyrosol was found in 3-phase dried RO retentate. Three, 4-Dihydroxyphenylglycol was tentatively identified by LC-MS. In dried RO retentate, 3-hydroxytyrosol and tyrosol were the predominant phenolic compounds. The trend in the phenolic compounds content determined by HPLC was in accordance to that obtained for the TSP by spectrophotometry. Among drying techniques, the highest concentration of the identified phenolic compounds was observed for spray-dried samples. The highest content of all identified compounds was established for 3-phase spray-dried RO retentate.

Approximately 20 olive growers and processors viewed the project summary presentation at the May 2015 meeting of the Olive Oil Commission of California. Approximately 70 academic and industrial scientists viewed the project posters at scientific meetings in 2014 and 2015.

Beneficiaries

More than 50 California olive processors benefitted from the completion of this project. The processors are able to see more return from the OMWW.

According to the economic analysis of the membrane separation process, there are very substantial potential economic values of the phenol-rich retentates, ranging from the hundreds to the thousands of dollars per day, can be gained by the processor. In addition, water values, associated with recovery and reuse of the water using in milling, are likely in the range of $10-$100/day.

Lessons Learned

Resin separation of valuable compounds from OMWW has been investigated by other chemistry laboratories in the past, so resin separation was included in the Work Plan as one of the techniques that would be explored. However, during the course of the project, it was learned that resin separation equipment was not available off-the-shelf for olive processors. The lesson learned was that availability of off-the-shelf commercial equipment should be the first criterion for technologies that will have industrial end-users.

During the economic analysis, it became apparent that the predominant cost for spray drying the RO retentate to a shelf-stable powder was the cost of maltodextrin – a carrier compound that is necessary to mix with the Reverse Osmosis (RO) retentate to get a final dried product. It was an unexpected result that this material cost would drive the economic viability of the drying process. While the filtration technology will drive down the cost of wastewater disposal, drying of the phenol-rich retentate may make the whole process less profitable for the processors. Therefore, it would be advantageous for the processor to look for markets that are interested in the wet phenol-rich concentrates from wastewater.

Additional Information

See Attachments:

1. Centrifugation as a Pre-Treatment in Olive Mill Wastewater Processing
2. Membrane Filtration for Enrichment of Phenolic Compounds in Olive Mill Wastewater
3. Olive Mill Wastewater Filtration Fraction: Drying Techniques and Quality Assessment of the Dried Product
4. Sustainable Technologies for Olive Mill Wastewater Management
5. Abstract
6. Olive Milling Wastewater Reuse

California Department of Food and Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.:	Project Title:	
41	Sustainable Easter Lily Production	
Grant Recipient: Northwest California Resource Conservation & Development Council	**Grant Agreement No.:** SCB12041	**Date Submitted:** December 2015
Recipient Contact: Mark Lancaster	**Telephone:** (530) 623-3967 x 111	**Email:** mlancaster@5counties.org

Project Summary

Field grown Easter lily bulbs can only be produced in a very small microclimatic area in Northwestern California (Del Norte County) and Southern Oregon (Curry County). Almost 100% of the Easter lilies that bloom for the Easter holiday come from this small area, where the lilies began being produced beginning during World War I, and by World War II, all of the bulbs used in the United States and Canada were being produced here. There is a limited amount of farmable acres on the coastal bench where lilies can be grown, so the same soils have been used for over 75 years. Very early in the young industry's growth (1940's), a number of problems arose, which were as follows: nematodes and symphylans eating off the roots, over 20 fungal and bacterial pathogens rotting the bulbs and roots, and a fungus that could defoliate the crop in a matter of days. It got to the point where Easter lilies could no longer be produced on anything other than "virgin ground," and there was no more "virgin ground" to be found in the area. There were no other areas with the right microclimate to move to. Easter lilies are susceptible to frost and will not "bulb" in areas with warm summers, and the lilies need to be grown in a heavy rich clay soil with abundant organic matter and sharp drainage.

Due to this situation, a grower funded research station was established in 1957, and one-by-one these mysterious problems were identified and eventually controlled with a system of cultural techniques and pesticide use. Soil fumigation was introduced to control soil born nematodes and symphylans. Bulbs were dipped in fungicides to control bulb rot. Pesticides were applied at planting to control bulb born nematodes. Pesticides were applied weekly to control the defoliating Botrytis disease. Pesticides were also introduced to control the aphids that vectored plant killing virus diseases. The lily crop was put into a four-year long rotation with three years of soil building cover crops (Grass Clover) between a single year of bulb growth to further diminish disease while building better soil structure and drainage.

Under the present state of the art production system, it takes three full years of field growth to obtain a commercial sized, salable Easter lily bulb. All bulbs are dug every fall, treated with fungicides, and replanted into a newly fumigated field taken out of its three-year soil building rotational crop. As such, Easter lilies require a very high amount of pesticides, labor, acreage, and fuel to grow to salable size. With both the cost of pesticides increasing and the availability of things like soil fumigants decreasing, growing Easter lilies has become more and more unsustainable.

There were two purposes of this project, both of which proposed to greatly reduce pesticide inputs in different fashions. Project staff proposed that, through breeding, a plant that could have sufficient flower count for commercial sales in its second field-growing year could be developed, thus cutting out the third growing season. Because the bulb field planting density decreases from the first, to the second, to the third years of growth, the third year takes roughly 50% of the total pesticides used in growing the crop. Thus, project staff hoped to achieve a 50% reduction in pesticides via this project objective. The second project objective was to introduce nematode anti-feeding genes into the Easter lily bulb. By doing so, project staff hoped to be able to eliminate an even larger percentage of pesticide use. Nematode control in this crop requires both soil fumigation and at-planting nematicides, both of which are fairly hazardous and expensive. Soil fumigants are by far the biggest pesticide input to the crop, requiring 550-600 pounds per acre per year, times the three years the bulb must be moved into a newly fumigated field.

Heavily dependent on soil fumigants for disease and nematode control, Easter lilies will be one of the first crops to no longer be in production if soil fumigants continue to become more restricted or not at all available. Other crops will follow if soil fumigants are taken away, so lessons learned from this project can be applied to other crops. Project staff have seen the decline in the number of soil fumigants, most recently methyl bromide becoming unavailable. Newer soil fumigants like “Midas”, developed by the University of California (UC) system, never received registration for use. Other fumigants project staff have tested have had odor issues, did not work, required plastic tarps, required techniques that would not work in this crop, or are just not available in the quantities or at the costs to be of practical use.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Easter Lily Research Foundation (ELRF**)**, located in the Easter lily growing area, managed the outdoor nematode field trials used in the project and conducted the breeding for the generation of the two-year type lily. The United States Department of Agriculture (USDA**)** located in Beltsville, Maryland, did the genetic engineering of the Easter lily to obtain and insert the gene, lab tested the resulting tissue culture lilies by challenging with nematodes, and provided tissue culture bulbs to ELRF for field resistance testing. University of California, Davis (UCD) Department of Nematology conducted the nematode field trials at ELRF and analyzed the nematode populations and yield data. The system requirements for field production of a two-year variety are like the current system requirements, but the third year is deleted, resulting in a 50% reduction of all inputs, pesticides, fuel, labor, land, and water. During the first year, one must plant lilies, scale them, and harvest the lily bulblets. During the second year, one must plant the lily bulblets and harvest commercial-sized greenhouse forcible bulbs. The current three-year system uses about 50% of land, water, pesticides, etc. in the third year due to the low planting densities (more square feet per bulb) required to fit the plants. The two-year system developed skips the third year by growing smaller bulbs with genetically enhanced (conventional breeding) bud count. ELRF released for grower field trials eight new two-year type varieties in October 2012. Three more two-year type lily varieties were released in August 2015. ELRF selected 45 new varieties in 2012, 49 in 2013, 41 in 2014, and 51 in 2015. These new varieties were selected from several thousand seedlings raised each year. Seedlings were field grown, selected for exceptional field traits, greenhouse forced, selected for exceptional greenhouse traits, and then placed in a “blind judging” show, where lily industry personnel judged the blooming plants. These selections, having passed field tests, greenhouse tests, and industry judging, were then cloned and multiplied, and now await grower field tests. ELRF has collected field harvest traits and greenhouse development data on these new varieties year-round to compare with current varieties. ELRF hosted a greenhouse judging show each Easter, a field tour of new varieties each June, an annual greenhouse data and photo report, and an annual field growth report during the project. These reports and events were provided to the Easter lily industry. ELRF had monthly grower meetings where grant progress and field production of both two-year and resistant lilies were discussed. At the grower meetings, spirited discussions occurred among the growers about the new lilies, as they could not wait to get the new varieties onto their farms to see how they grow.

ELRF also planted, maintained and harvested the USDA nematode resistant field tests for UCD and USDA. USDA obtained nematode resistance genes from England, made constructs, and inserted resistance genes into conventional "Nellie White" Easter lilies. From a number of transformed plant lines, laboratory tests were used to screen for the presence of resistance genes being expressed in transformed lily plants. These tests then identified the five transformed plant lines with the most resistance, which were then cloned and tissue culture propagated to increase numbers for testing. USDA then conducted three additional laboratory nematode challenge tests, measuring root numbers, bulb weight, root weight, and nematode infection. All three tests showed improved bulb growth and lowered nematode infection. USDA then tissue culture propagated additional numbers of these five clones and the control for shipment to ELRF for field-testing. ELRF and USDA worked together on the USDA-Biotechnology Regulatory Services (BRS) permit required for transporting and field-testing genetically engineered plants. The permit was granted and USDA shipped ELRF the tissue cultures for field-testing. UCD designed the field test challenging the varieties with nematodes under four different conditions: full commercial nematode control, fumigation only, nematicide only, or no chemical control at all. The first field test was small, given the small bulb sizes from tissue culture. As the first test was planted with the larger bulbs, the smaller bulbs were greenhouse grown over the summer to gain enough size for a successful second fall planting trial that was evaluated in June 2015 and harvested in Fall 2015. USDA published a paper "Expression of a cystatin transgene can confer resistance to root lesion nematodes in Lilium longiflorum cv.'Nellie White'" in the journal Transgenetic Research in November 2014. UCD conducted two field trials of the USDA resistant lilies. UCD brought a nematode extraction lab up to the ELRF site to count nematodes on site, as an additional USDA permit would have been required to move the plant roots to the UCD lab in Davis. UCD conducted several field trials testing "soft" pesticide methods of nematode control, such as biologicals and botanicals to enhance nematode control. UCD designed, planted, harvested, and took all data in the field-testing of the USDA resistant lilies. UCD calculated and graphed the data for the USDA field tests.

This project only directly benefited Easter lilies, a specialty crop.

There were three partners on this project: USDA, ELRF, and UCD. USDA researched and obtained nematode resistant genes and inserted them into Easter lilies. USDA tested the transformed lilies for gene expression in the lily roots then challenged the converted bulbs in the lab to nematodes in three separate tests. USDA grew quantities of the resistant lilies in tissue culture to provide planting stock for two field tests. USDA helped ELRF gain permit approval for transportation and field-testing of a genetically modified (GMO) crop. USDA published a paper on the resistant Easter lily research. UCD conducted field-testing of the nematode resistance of the USDA lilies. UCD brought a lab to extract nematodes to the field site, planted, harvested and obtained field test data. ELRF assisted both UCD and USDA in the above project. ELRF bred thousands of seedlings and selected 186 new types with potential to be two-year lilies. ELRF kept field and greenhouse records/growth data on the new types of two-year lilies. ELRF held three greenhouse blooming judging events, three field tours of new varieties and two tours of the USDA/UCD resistance trials. ELRF has released 11 new varieties for field-testing. ELRF has reported results of UCD, USDA, and ELRF research to the growers. ELRF has coordinated the trial work between UCD, USDA, and the public outreach to the lily bulb growing community.

Goals and Outcomes Achieved

In order to reduce fumigant pesticide, nematicide, and fungicide use of the Easter lily industry, project staff genetically engineered lilies to resist nematodes. The resistant lilies were lab and field-tested. Selective conventional breeding occurred to create lilies that respond as a three-year plant when only two-years old. Project staff field and greenhouse tested the new two-year lilies. The new two-year lilies were propagated to release for grower field-testing.

Eleven new types of two-year lilies are in the process of commercial field-testing. As these new types become accepted in the trade and propagated by the growers, there will be a shift from the production of three-year lilies to two-year lilies. Then, yearly reductions in pesticide use with the two-year lilies requiring 50% less than the three-year lilies should be seen. At this point the USDA lilies do not seem to be resistant enough under field conditions to allow reduction of pesticide inputs, but USDA continues to identify additional genes to be used for nematode resistance in lilies outside of this grant.

Two-year type lilies have been created, field and greenhouse tested, propagated, and released for testing by commercial growers. As commercial field and greenhouse growers accept the two-year type lilies, there should be a yearly reduction in pesticide use as they replace the three-year type lily. Genetically, nematode resistant lilies were created, lab and field tested, but do not seem to have sufficient field resistance for commercial use.

From the breeding and testing of thousands of seedling bulbs, project staff have selected 91 new varieties that have the potential to be two-year type lilies. 2012=21, 2013=25, 2014=20, 2015=25 Total =91.
Eight new two-year type varieties are currently in grower field trials and three more were released to growers in September 2015. A nematode anti-feeding gene was obtained and successfully inserted into an Easter lily. Project staff were successful in gaining USDA-BRS approval for moving and field testing a GMO lily. A system to field-test tissue cultured genetically engineered lilies was established.

Beneficiaries

The project benefits the Easter lily field growing industry ($7 million farm gate) with 2,200 acres of cropland by allowing a reduction in production costs including pesticides, fuels, labor, fertilizers and other costs. The project also benefits an additional 320 greenhouse growers ($27 million industry) who will see a reduction in shipping costs, growth regulator chemicals, bulb costs, heating costs, and pesticide inputs. Finally, the project benefits the retail consumer ($77 million industry) who will receive a healthier plant with a longer bloom period that was grown by much more sustainable farming methods.

The four field-growing farms that produce the entire Easter lily crop should be able to reduce pesticide, fertilizer, fuel, and labor inputs by about 50% when converting to the two-year cropping system. 320 Greenhouse growers will see reduced bulb shipping costs, the total elimination of the use of plant height controlling growth regulators, the negative side effects of growth regulator use, a reduction in greenhouse heating costs, and a reduction in bulb costs.

12,000,000 consumers will receive a higher quality plant that was grown more sustainably at a reduced cost.

Lessons Learned

Movement of transgenetic plants or plant parts from one location to another requires a permit from USDA-BRS. Project staff obtained a permit to move the plants from USDA to ELRF. These permit applications are lengthy, complicated, and take a month or more to receive approval. It would have required an additional permit to move the post-trial root samples to the nematode lab at UCD for analysis of nematode populations. Instead, UCD constructed a portable lab and brought it up to the ELRF field test site where UCD conducted nematode extractions and counts onsite. Project staff applied for a similar permit to ship bulbs harvested from the first trial back to USDA. By the time the permit was granted, the bulbs had rotted in refrigerated storage. UCD's portable lab saved time and allowed the harvest samples to be in prime condition.

The disparity between lab results and field results of the nematode resistant lilies was disheartening. The lesson would be to field test as soon as possible after a single positive lab test rather than conducting three lab tests before a field test. Multiple lab tests may be required for publication of results, but field testing should begin sooner.

Project staff saw a couple of unexpected outcomes in the breeding portion of the project. As a result of achieving higher flower count on smaller bulbs, project staff developed a new bud display architecture. This architecture gives each flower its own stem in a progressive spiral pattern up the stem. As a result, consumers will gain a longer period of flower display and greenhouse growers will have less problems with bud blast or bud abortion. The second outcome was an earlier blooming trait, with some of the new two-year lilies blooming in from 96 to 104 greenhouse days, whereas the conventional three-year lily takes 117 days to bloom. The result will be that greenhouse growers could shave off as much as three weeks of heating costs, a substantial savings for mid-eastern greenhouse growers in the winter months.

The different responses in nematode resistance between lab tests versus field tests resulted in a goal not fully achieved. One outcome of the project was to reduce the use of pesticide on Easter lilies by 85,500 pounds per year, lowering the risk of insects adapting and becoming immune to the effects of commonly used chemicals. While the second year trial remains to be dug, the foliar vigor at this time suggests that the converted lilies need both soil fumigation and row treatments to grow. Lilies are not doing well, in fact dying, in untreated soil, and they are much less vigorous without in-furrow nematicide. None of the converted lilies appear to have sufficient nematode resistance in the field to allow a 50% reduction in pesticide use. The two-year type lilies do; however, allow pesticide reduction which could reach 50% with full adoption of the new varieties. Moving more quickly to the field testing stage after just one lab test would have brought this difference up more quickly. Additional anti-nematode genes that were not available when this grant started are currently being obtained. The USDA identified these genes during the course of this grant. USDA is seeking additional grants that will allow the insertion into Easter lilies.

Additional Information

The attached documents convey completion of achieving outcomes. The new two-year type bulbs give a plant with the same height, plant picture, and bud count as the current three-year type bulb. The judging data show that the two-year type bulb is acceptable to the trade, getting better scores in "blind judging" than the current three-year type. The field harvest data shows the two-year type bulb can produce greenhouse forcing sized bulbs in two years rather than three years. Additional data is available upon request.

- Attachment 1: USDA Lab Nematode Resistance Tests #1, #2, #3 and photos.

- Attachment 2: USDA publication PDF "Expression of a cystatin transgene can confer resistance to root lesion nematodes in Lilium longiflorum cv.'Nellie White'"
- Attachment 3: ELRF 2012 and 2013 Greenhouse reports (Contain data on new two-year type lily greenhouse data)
- Attachment 4: ELRF Greenhouse Judging reports for the years 2012-2013, 2013-2014, and 2014-2015 (Contain data on new two-year type lily grower judging results)
- Attachment 5: ELRF New Greenhouse Selections Photos, for years 2012, 2013, 2014, 2015
- Attachment 6: USDA-BRS documents outlining applications to move transformed lilies, design protocols, permits.
- Attachment 7: ELRF Root score key, visual aid to nematode control

USDA Project No. 42	Project Title: Improving Water Use Efficiency in High Elevation Vineyards	
Grant Recipient: Calaveras Winegrape Alliance	**Grant Agreement No.:** SCB12042	**Date Submitted:** December 2015
Recipient Contact: Carrie Nelson / Nanette Tanner	**Telephone:** (209)728-9467	**Email:** cwagrant2@gmail.com

Project Summary

The purpose of the project was to "Improve Water Use Efficiency in High Elevation Vineyards". In the U.S., agriculture has accounted for 70% of water use. Water supplies are increasingly diminishing, so there is a critical need to develop agricultural methods that will use the water more efficiently. It was anticipated that high elevation (HE) vines using irrigation schedules based on 10 day predictive high temperature forecasts would benefit differently (i.e. save more water) from HE vines using traditional irrigation practices.

As politicians and water experts scrutinize agriculture's use of water in California, it is important and timely to adopt water saving practices that are economical & sustainable. California is currently in a drought and use of the irrigation model has proven to reduce water consumption by ±20%. Water saving practices are especially important for growers in HE regions because of the arid climate conditions experienced during the growing season. Using standard irrigation practices in HE vineyards, plant water loss during high temperature episodes can be +30% with fruit yield reductions estimated to reach 50%.

This project complemented and enhanced work completed under prior 2011 Specialty Crop Block Grant Program (SCBGP) Project 27: *Improving Water Use Efficiency in High Elevation (HE) Vineyards* which created a draft water efficient irrigation model that was tested in two vineyards. In the current project the draft irrigation model was tested in four HE vineyard sites, each with different plant varietals, root stocks, and historic irrigation practices. Research results illustrated the need to exclude vineyards planted in high water holding capacity soils from utilizing the model. The irrigation model was enhanced by the development of a user friendly computer model prototype. The online model will be available in the summer of 2017. The online tool uses the forecasts from the Weather Underground website.The online irrigation model prototype states when and how much a grower should irrigate. With the click of a button a recommended irrigation directive should appear on the screen stating to either "Irrigate today", "Irrigate tomorrow" or "Don't irrigate at this time". In addition it also gives you a warning that you may need to irrigate in the near future.

Project Approach

Each season, irrigation trials were conducted in two vineyards; each with test and control blocks so that the efficiency of the Model could be assessed. The vineyard test blocks were irrigated per the Model directives and the control blocks were irrigated as normal. The vineyards selected provided varied plant varietals, root stocks, elevations, soil types, and 'normal irrigation' procedures.

Tasks performed included trial setup, soil sampling and analysis, installation of weather and soil moisture sensors, tracking of weather and soil moisture data. Record keeping tasks included irrigation data, the Model's daily recommended irrigation directives, plant moisture stress (PMS) and leaf conductance levels.

Vineyard and harvest tasks included photographing vine growth, collecting vine leaves to conduct petiole sample tests for plant nutrition levels, harvesting sample grapes and recording the weights, using juice and wine from harvested grapes to perform analysis for quality comparisons in test and control blocks. Computer and online tasks included creating and uploading the Model's program to the California Winegrape Alliance (CWA) website, evaluating and improving the Model's performance, adjusting the online irrigation tool to make it more user friendly and performing statistical analysis.

Outreach tasks included contacting various agricultural organizations, agricultural commissioners, University of California Cooperative Extension Program (UCCE) farm advisors and other interested parties. Activities of the project included outreach presentations to grower associations, the CWA board of directors, attendees of agricultural events, UCCE farm advisors and agricultural commissioners. In addition monthly project status updates were provided to the CWA board of directors and monthly project team staff meetings were held which were open to the public.

Overall, the most significant result accomplished was an alpha tested, user friendly online irrigation tool which during alpha testing, increased water savings by 20% or more with no negative effects on crop tonnage, grape quality or plant health. In conclusion, beta testing the model was recommended by high elevation vineyard specialist of Viticulture & Plant Science Advisor, from UCCE-Mendocino County to minimize grower risk and assure expected performance.

An unusual development was the test block used more water than the control block in the El Portal vineyard~~s~~, which has high water holding capacity soils. It appears that soils with high water holding capacity do not dry out as rapidly as other soil types and therefore do not require as much irrigation water. The overall scope of the project did not benefit commodities other than HE wine grapes, a California specialty crop.

Project partners associated with this project have provided outreach and support. These cooperating entities include the Calaveras County Farm Bureau, Calaveras Grown, and the Calaveras County Ag Commissioner's office. The Calaveras County Farm Bureau provided outreach to its board of directors and members at large in a power point presentation on the water saving efficiency of the HE vineyard irrigation tool and included follow-up information regarding the tool in its membership newsletter. Calaveras Grown has provided an opportunity for outreach to its membership to review the water saving efficiency of the irrigation tool. The Calaveras County Ag Commissioner's office supported the project by providing technical information regarding wine grape growing areas in the region, maps and GPS data. A presentation of the project's status was presented at the UCCE/Calaveras Winegrape Alliance's Vineyard Tour (July 19, 2013); attendees included UCCE Central Sierra Farm Advisor and UCCE Sonoma County Viticulture Advisor.

Goals and Outcomes Achieved

The primary performance goal of this project was to improve water use efficiency in high elevation vineyards by testing and modifying irrigation models developed in the 2011 SCBGP Project 27. Activities completed to test the model included setting up test and control blocks in two vineyards each season; test blocks were irrigated per the model and control blocks were irrigated per the grower's normal watering schedule. Water use data from the test and control blocks was collected and evaluated; results indicated that by following the model's directives a 20% average of water saved could be realized. Activities completed to modify and improve the model included collecting grower feedback, studying and comparing weather websites, working with a computer programmer and working with a website designer.

The measurable outcomes identified in this project were a 20% reduction in water usage, a 10% increase in crop tonnage and positive increase or reading in grape quality. Activities completed to achieve a 20% reduction in water usage were done by comparing irrigation data in the test vs the control blocks over the two year period. This goal was met in 3 of the 4 tested vineyards which established the fact that vineyards planted in soils with high water holding capacity should not use this model. Activities completed to determine a 10% increase in tonnage included weighing grapes harvested from two vines in test blocks and two vines in the control blocks. In 2014, weights from one of the test blocks was 7 pounds heavier than the control block and weights from the other test block were 3 pounds heavier than the control block. In 2013 the target goal of a 10% increase in crop tonnage did not occur. Activities completed to evaluate grape quality included basic and enhanced juice panel lab tests for quality comparisons in test and control blocks and no significant differences were noted.

The outcome measures were seasonal, and water used, crop tonnage and grape quality were measured each season. However, the long term use of this project may reduce water waste, protect the limited water supply in California and reduce costs for high elevation vineyard growers as well as others that may use the practices of this project.

Any reduction in water use; any increase in crop tonnage or any increase in grape quality was considered a positive measurable outcome. Goal #1 was a 20% reduction in water usage which was successfully obtained. Goal #2 was a 10% increase in crop tonnage which was not fully obtained; however in some vineyards a less than 10% increase in tonnage was realized. Goal #3 was to produce a positive increase or reading in grape quality measurements. The one increase in quality measurement that was met in all test vines was higher Yeast Assimilable Nitrogen (YAN) readings. Higher yeast assimilable nitrogen aids in the fermentation process of wine making. Other routine test panels were conducted on the juice and wine from the test and control blocks. There were no significant differences found between the test and control samples in these other panels.

Baseline data for all targets was gathered from all test vineyards. See attachment 1 for a baseline information comparison. To achieve set targets, the amount of water used in control blocks (watered based on the normal historic watering duration and frequency) was compared to the amount of water used in test blocks (watered based on the Models irrigation directive which dictated when and how much water to apply) in four vineyards. To achieve set targets the amount of grapes harvested in control blocks were compared to the amount of grapes harvested in test blocks in four vineyards. To achieve set targets juice and wine tests results from control blocks were compared to juice and wine tests results from test blocks in four vineyards.

A major successful outcome of the project was the development of the Model's user friendly online irrigation tool for watering wine grapes, a California specialty crop. The other major successful outcome of the project was a water savings of more than 20% by using the Model.

Beneficiaries

Growers of high elevation wine grapes benefitted from the completion of this project's accomplishments. At this time, six vineyards benefitted from the Model's directives. The water savings in these vineyards ranged from a deficit of 27% to a savings of up to 38%. This reduction in water usage resulted in various financial savings. Once the Model is beta tested and released to the public, more growers will realize the financial savings and the state of California will benefit from the water saved.

It is estimated that the high elevation growers of wine grapes in the more than 20,000 acres of vineyards at 1,000+ ft. elevation in California could be affected by the accomplishments and resulting potential economic impact of this project. These high elevation wine grape growers are located in Lake, Mendocino, Calaveras, Amador, Tuolumne, El Dorado, Napa, Monterey & San Luis Obispo counties.

Lessons Learned

As a result of completing this project lessons learned by the Calaveras Winegrape Alliance project staff included the fact that the project team should have budgeted and requested funding to beta test the developed Model, after which the completion of a BMP could then be released to the public. Another lesson learned is we should have estimated budget categories more accurately and thus budgeted line item expenditures more appropriately rather than requesting 4 line item shifts for the 2 year project.

An unexpected outcome of implementing this project was the non-completion of a best management practices (BMP) which necessitated changes to the work plan. The BMP could not be completed because the Model has not been beta tested. It is highly recommended that the Model be beta tested before public release.

Another unexpected outcome of the project was the realization that the use of the Model did not save water in vineyards with high water holding capacity soils. Because the Model provides irrigation directives based on spikes in temperature, the vineyard with the high water holding capacity was irrigated numerous times during the growing season, based on temperature spikes. Using its normal irrigation practices, this vineyard would not have been irrigated as often, therefore it would have used less water than the Model directed.

A lesson learned in not being able to complete and release an irrigation BMP to the public is that by using more and varied test sites, limitations of the Model could be identified earlier and thereby reduce user risk. Beta testing would help achieve that goal.

Additional Information

None.

USDA Project No.: 43	**Project Title:** Determination of post fumigation recovery of soil microbial communities over time	
Grant Recipient: United States Department of Agriculture, Agricultural Research Service, Water Management Research	**Grant Agreement No.:** SCB12043	**Date Submitted:** December 2015
Recipient Contact: James Gerik	**Telephone:** (559) 596-2865	**Email:** james.gerik@ars.usda.gov

Project Summary

High value crop producers in California rely heavily on soil fumigation to control a wide array of target soil borne pests including nematodes, pathogens and weeds. It is known that the fumigants with broad biocidal activity can affect non-target soil microbial communities. It is often thought that microbial communities in soil make a relatively rapid recovery soon after the application of fumigants. However, repeated application of fumigation for a long period of time can affect recovery of soil microbial communities compared to short-term fumigation events where microorganisms are recovered quickly due to versatile crop rotations. It is important to study the effect of soil microbial communities in continuous fumigated lands as soil microorganisms are crucial in sustaining health of agricultural soil by contributing to nutrient cycling, plant nutrient uptake, and agricultural productivity. It is essential for beneficial soil microorganisms to improve after fumigation for the development of healthy soils. Understanding of it is critical to understand how microbial communities are impacted and what can be done to further preserve these fumigated lands. Therefore, the main objective of this study is to determine the effect of long-term continuous application of fumigants (15, 33 and 39 years since fumigation) on soil microbial communities and compare them with non-fumigated and organic sites.

It is known that the fumigants with broad biocidal activity can affect both target and non-target soil organisms, but the recovery of belowground components of the ecosystem such as microbial community and soil structure are largely unknown until recently. Therefore, there is an immediate need to study the microbial community recovery soil microorganisms are crucial in sustaining health of agricultural soil by contributing to nutrient cycling, soil structure, and overall soil quality. This project has great impact on specialty crop producers that use soil fumigation because several short-term studies on recovery of soil microbial communities in fumigated fields have concluded that soil microbial communities make a relatively rapid recovery (less than a year) after the application of fumigants. However, long-term continuous application of fumigants can have significant and lasting impacts on soil microorganisms than single fumigation events.

This project was not built on a previously funded Specialty Crop Block Grant Program project.

Project Approach

With good collaboration and multidisciplinary team efforts, methyl bromide fumigated and non-fumigated fields were selected across the Watsonville area on the basis of data provided by the fumigation industry and grower interviews. With the samples collected in May and November of 2013, project staff successfully completed studies on the effect of long-term continuous fumigation on soil microbial communities, and organic farming and long-term methyl bromide fumigation on soil microbial community composition.

Long-term continuous fumigation on soil microbial communities:

The study was conducted in the Watsonville, California. The chronosequence selected for this study contained four sites defined by number of years since fumigation with methyl bromide. The sites were Darrel 15 year old fumigated site (15 DAR) (36^{o}56’26.6”N 121^{0}43’15.9”W) where the grower fumigated for fifteen years at the time of sampling, a thirty-three years since fumigation coastal callas site (33 CC) (36^{o}52’37.1”N 121^{0}40’41.4”W), a thirty-nine years since fumigation growers (ROD) site (39 ROD) (36^{o}54’12.0”N 121^{0}49’25.4”W), and three representative never been fumigated sites from Darrel’s site (DAR), coastal callas (CC) and Rod’s 39 year old fumigated (ROD) organic site as a control. Soil samples were collected from 0-5, 5-15 and 15-30 centimeters (cm) depths. Three, one-hundred meter transects, serving as replicates, were randomly placed on research sites; and soil samples were collected from four equally spaced points along each transects. Due to the difficulty in finding fumigated sites of the same age and with the non-fumigated, organic, and methyl bromide treatments, each transect was considered a replicate, and the four sampling points were not composited. Project staff measured pH, electrical conductivity (EC), concentrations of calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), sulfur (S), dissolved organic carbon (DOC), total nitrogen (TN), total carbon (TC), percent water-stable aggregates, mean-weight diameter as well as microbial community structure and biomass.

In order to understand the long-term continuous application of fumigants on soil properties, macronutrients and TC, TN, and dissolved organic carbon were determined (Table 1). Soil pH was generally similar in different aged fumigated sites, organic and non-fumigated sites. Concentrations of Ca, K, Mg, Na and S were significantly higher in non-fumigated DAR site compared to organic and other fumigated and non-fumigated sites where it remained similar to each other. Dissolved organic carbon, TN and TC varied between fumigated and non-fumigated sites. Dissolved organic carbon was higher in non-fumigated DAR, organic and 15 and 39 years since fumigation sites than 33 and coastal calla sites. Total N was higher in non-fumigated DAR, organic, 15 and 33 years since fumigation sites. Total C was significantly higher in non-fumigated coastal calla site.

Soil microbial community biomass represented by total Phospholipid Fatty Acid (PLFA) was significantly higher ($p<0.05$) in CC NF as compared to other fumigated and non-fumigated sites at 0-5 cm depth (Figure 1). At the 5-15 cm depth, total PLFA in CC NF was higher than in organic and site fumigated for 39 years whereas at 15-30 cm depth, total microbial biomass in non-fumigated sites (CC and DAR) were higher than 15 and 39 years old fumigated sites (Figure 1).

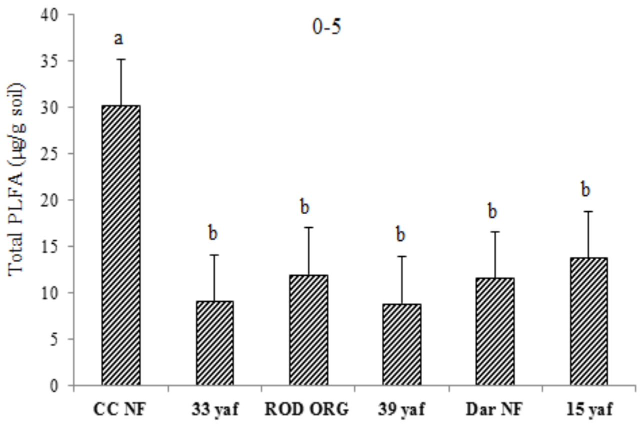
Fungal PLFA was much higher in 15 year old fumigated site than in other fumigated, non-fumigated and organic site at 0-5 cm depth (Table 1). Arbuscular Mycorrhizal Fungi (AMF), Gram positive, Gram negative, actinomycetes and eukaryotic PLFAs were higher in non-fumigated CC site as compared to other fumigated and non-fumigated sites at 0-5 cm depth. In 5-15 cm depth, 15 year old site had significantly higher fungal PLFA than in other non-fumigated and organic sites. Higher AMF in non-fumigated site from coastal callas (CC NF) site than in 15, 33 and 39 year fumigated and no difference in organic and ROD non-fumigated sites were observed. CC NF had higher Gram positive, Gram negative, actinomycetes than in other fumigated and non-fumigated and organic sites. CC NF and 15 year fumigated sites had higher Eukaryotes than in organic site. At the 15-30 cm depth, no significant differences in fungi, Gram positive bacteria, Gram negative bacteria and actinomycetes were observed. However, significantly higher AMF in DAR NF than in fumigated and non-fumigated sites and higher eukaryotes in CC NF than other sites were observed.

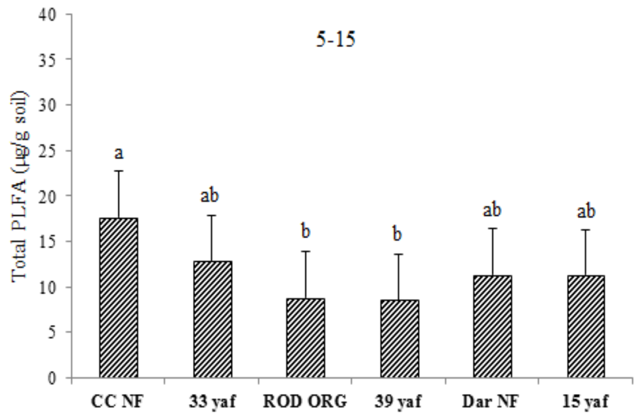
Canonical multivariate analysis of variance suggests that differences in the microbial communities in fumigated and non-fumigated sites are significantly ($p<0.05$) different. However, greater similarities were observed among older fumigated 33 and 39 year old sites. Similarities were also observed among non-fumigated DAR and organic sites. Also, CC NF and 15 year old sites are distinct from one another as well as the other fumigated sites at 0-5 cm depth. At 5-15 cm depth, differences between fumigated and non-fumigated sites remain significant; all the fumigated sites remained in a close proximity as compared to non-fumigated sites where differences were greater. At the deeper depth, CC-NF site was distinct from all other fumigated, non-fumigated and organic sites.

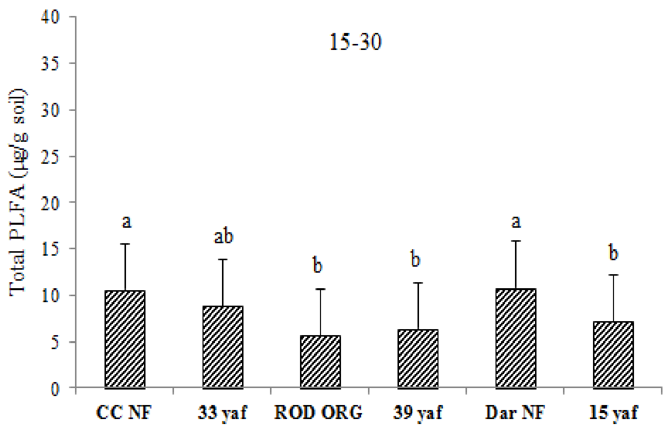
Microbial indicator	Depth	CC NF	33 yaf	ROD ORG	39 yaf	DAR NF	15 yaf
Fungi	0-5	0.67bc*	0.21c	0.44bc	0.39bc	0.3c	1.47a
	5-15	0.39b	0.46ab	0.33b	0.63ab	0.26b	1.29a
	15-30	0.14	0.17	0.12	0.21	0.22	0.34
AMF	0-5	0.74a	0.11d	0.55b	0.22cd	0.38bc	0.35bc
	5-15	0.52a	0.16c	0.44ab	0.3bc	0.45ab	0.25bc
	15-30	0.24ab	0.1b	0.22ab	0.18b	0.38a	0.17b
Gram + bacteria	0-5	8.41a	3.56b	4.11b	3.61b	4.02b	3.63b
	5-15	5.89a	4.32b	2.96bc	2.68c	4.08b	3.34bc
	15-30	3.28	2.74	1.91	2.13	3.81	2.52
Gram - bacteria	0-5	13.37a	3.29b	4.93b	3.61b	4.88b	5.76b
	5-15	7.13a	5.56ab	3.65bc	3.34c	4.54bc	4.43bc
	15-30	4.03	4.11	2.22	2.4	4.29	2.72
Actinomycetes	0-5	4.56a	1b	1.4b	0.93b	1.5b	1.21b
	5-15	2.33a	1.33bc	0.95bc	0.82c	1.43b	1bc
	15-30	1.27	0.71	0.67	0.67	1.38	0.79
Eukaryotes	0-5	1.88a	0.49cd	0.35cd	0.52cd	0.25d	1.16b
	5-15	0.91a	0.52ab	0.36b	0.55ab	0.37ab	0.77a
	15-30	0.38a	0.48b	0.37b	0.5b	0.47b	0.46b

Table 1 above. Gram positive bacteria, Gram negative bacteria, fungal, AMF and actinomycetes phospholipid fatty acids (PLFAs) for fumigated and non-fumigated sites

Figure 1 below. Total PLFA for fumigated and non-fumigated sites at 0-5, 5-15 and 15-30 cm depths. Different letter indicate significant differences ($p<0.05$). Samples were collected from 33 year old fumigated as well as non-fumigated sites from coastal callas (CC), 39 year old fumigated and organic site from ROD and 15 year old fumigated and non-fumigated sites from Darrel (DAR) sites.







Organic farming and long-term methyl bromide fumigation on soil microbial community composition:
A field study was carried out to analyze the effect of organic farming and long-term continuous fumigation on soil microbial biomass and community structure in strawberry fields located in Watsonville, California. In California, high values crop producers rely heavily on soil fumigation to control soil borne pests including nematodes, pathogens and weeds. However, the fumigants with broad biocidal activity can affect both soil borne pests and beneficial microorganisms. Beneficial microorganisms help in nutrient cycling, plant nutrient uptake and soil structure development. After the phase out of methyl bromide, new fumigants have been used and farmers are concentrating on soil quality and soil health. The goal of this study is to determine the effect of fumigation on soil microbial communities and compare than with organic farming.

Samples were collected in May and December of 2013. In May 2013, samples were collected from 39 year old continuous fumigated site and an organic site, which was established in 2006. In December 2013, samples were collected from the same 39 year old plot and an organic plot which was established in 2013. Strawberry fields were selected across the Watsonville area on the basis of data provided by the fumigation industry and grower interviews.

Soil properties such as macronutrients and TC, TN, and DOC were determined in organic sites as well as long-term fumigated sites. Total carbon and total nitrogen were significantly higher in 39 year old fumigated site as compared to other organic and fumigated sites. Samples collected from organic site in December contained significantly higher DOC. Fumigated 39 year old site had higher Ca and S. Soil pH was lower in 39 year old fumigated site as compared to organic and 40 year old fumigated site, whereas, EC generally remained similar in all the sites

Total PLFA was significantly higher in soil samples collected from organic site in May, 2013 as compared to other organic and fumigated sites at 0-5 cm depth. However, no significant differences between organic and fumigated sites were observed in deeper depths.

Fungal populations significantly decreased in both fumigated sites and organic samples collected in December as compared to May organic site. No significant differences were observed in organic and fumigated samples collected in December. AMF, Gram positive and Gram negative bacterial eukaryotic phospholipid fatty acids (PLFA) was significantly higher in organic May sites than fumigated and organic December sites. However, eukaryotic PLFA showed a different trend, where, organic site that was recently established and 39 year old fumigated sites had significantly higher eukaryotes as compared to 40 year old fumigated site. At the 5-30 cm depth, AMF population was significantly higher in organic site established in 2006 as compared to recently established organic site. Actinomycetes PLFA was significantly higher in organic and fumigated samples collected in May as compared to December sites.

At the 0-5 cm depth, fumigated and organic samples collected in May were significantly different to each other and also than Dec samples. No significant difference was observed between fumigated and organic samples collected in December. Whereas, at 5-30 cm depth, fumigated and organic samples collected in May and December were similar to one another but significantly different. Discriminant analysis shows that samples collected in December from fumigated and organic soils were significantly different than samples collected in May at 0-5 and 5-30 cm depths.

This study showed that older organic sites harbor significantly higher microbial biomass as compared to long-term fumigated sites as well as younger organic site. Several other studies also have shown that organic farming leads to higher soil quality with higher microbiological activity than conventional farming, due to versatile crop rotations, and the absence of pesticides.

Non-specialty crops do not use soil fumigants; therefore, this project benefits only specialty crops.

The multidisciplinary teams representing Agricultural Research Service (ARS) and University of California, Davis (UCD) have conducted collaborative research for this project, such as field selection, soil sampling, and physico-chemical and soil analysis. Soil physico-chemical and plating assay was the responsibility of ARS and UCD. Microbial community analysis was conducted by UCD researcher Co-PD.

Goals and Outcomes Achieved

Throughout the course of this project, soil samples were collected twice in May and December of 2013. Project staff organized and compiled soil biological and soil chemical data. Project staff measured pH, EC, concentrations of Ca, K, Mg, Na, S, DOC, TN, TC, Percentage Water Stable Aggregates (%WSA), Mean-weight Diameter (MWD.) Soil microbial biomass, microbial community composition such as Gram positive bacteria, Gram negative bacteria, fungi, AMF, eukaryotes and actinomycetes as well as data for non-target organisms such as Pythium spp. and Fusarium oxysporum, were analyzed. The results suggested that repeated application of fumigation for a long period of time can affect recovery of soil microbial communities compared to short-term fumigation events where microorganisms are recovered quickly due to versatile crop rotations. Therefore, it was concluded that it is very important for beneficial soil microorganisms to improve after fumigation for the development of healthy soils. Therefore, it is essential to understand in detail how microbial communities are impacted and what can be done to further preserve these fumigated lands. All proposed tasks are met fully and completed during the course of the project.

The study confirms that repeated application of fumigation for a long period of time affects soil microbial communities compared to short-term fumigation events. Therefore, the future plan is to determine if reinoculation of fumigated soils with specific microbes (Arbuscular Mycorrhizal fungi, rhizosphere bacteria, etc.) facilitate recovery of soil microbial communities and plant growth. The project will have long-term impact on growers by deploying beneficial microorganisms to improve crop productivity with less or no fumigation and also to restore fields of several high-value crop growers applying soil fumigants over a long period in California. Since soil microorganisms are critical in sustaining health of agricultural soil by contributing to nutrient cycling--plant nutrient uptake, it is very important to know the effect on soil microbial community structure.

The goal of this project was to focus on creating awareness among California farmers about the importance of redevelopment of good soil structure and soil biological processes on soil quality and soil health which in turn are essential to the agricultural sustainability and productivity. The main research objective was to examine the recovery of belowground ecosystem components in long-term fumigated sites. The long-term continuous annual application of methyl bromide and other fumigants and their effect on several beneficial soil microorganisms are not known until recently. Therefore, in this study, the focus was on the field sites where methyl bromide has been applied annually for 15, 33 and 39 years. This study showed that microbial communities such as fungi, AMF and eukaryotes were significantly higher in recent fumigation i.e. 15 years as compared to 33 and 39 year continuous fumigation sites. Gram positive bacteria and actinomycetes did not change significantly with repeated fumigation events. Canonical multivariate analysis showed that non-fumigated and organic sites were significantly different than fumigated fields. Additionally, older fumigated (33 and 39) sites were similar to one another, however, differed significantly from 15 year old site.

Prior to this project, the effects of long-term repeated application of fumigants on beneficial soil microbial communities were not known. This study confirmed that the long-term repeated use of fumigation have more significant and lasting impacts on soil microbial populations that have been measured in single fumigation events studies.

This study also showed that microbial communities such as fungi, AMF and eukaryotes were significantly higher in recent fumigation i.e. 15 years as compared to 33 and 39 year continuous fumigation sites. Lower fungal biomass is typical of intensively cultivated agricultural soils and it has been attributed to different factors such as physical disturbance, and altered amount and complexity of nutrient inputs and decrease in soil organic matter as compared to undisturbed soil. Other studies have also concluded that fungal and arbuscular mycorrhizal fungal populations were sensitive to fumigation.

Gram positive bacteria and actinomycetes did not change significantly with repeated fumigation events. Gram positive bacteria were less injured by fumigation and due to protection by the cell wall structure of the bacteria by formation of spores and ability to adapt to fumigant vapor more quickly.

Microbial biomass was significantly higher in the 33 year old site as compared to the non-fumigated site. Management of site also plays an important role in microbial community structure and biomass recovery.

Dissolved organic carbon was higher in non-fumigated Darrel's 15 year old fumigated site (DAR), organic and 15 and 39 years since fumigation sites than 33 and non-fumigated (NF) coastal calla sites. Total N was higher in non-fumigated DAR, organic, 15 and 33 years since fumigation sites. Total C was significantly higher in the non-fumigated coastal calla site.

Older organic sites harbor significantly higher microbial biomass as compared to long-term fumigated sites as well as the younger organic site.

Microbial community structures in non-fumigated and organic sites were significantly different than fumigated fields. Additionally, older fumigated (33 and 39) sites were similar to one another, however, differed significantly from the 15 year old site.

Beneficiaries

It is often assumed that the soil microbial community makes a rapid recovery from fumigation events but long-term fumigation has resulted in the abandonment of several fields in California. This study will benefit floriculture, fruits and nuts industries. Data can also be used by other specialty crop growers. Pre-plant soil fumigation with methyl bromide and alternative fumigants reduce the level of plant pathogens and the practice has become an important agricultural routine. Also, soil fumigation reduces the nonpathogenic organisms of the native soil microbial community which can result in a reduced competitive environment for pathogens as well as lesser organic matter degradation and nutrient mobilization. Therefore, the outcome of this research provides field data to the specialty crop growers on beneficial soil microorganisms affected by continuous fumigation for a long period of time.

The scope of the project benefited floriculture industries, mainly cut flower, bulb and ornamentals as well as fruits and nuts industries such as almonds, grapes and strawberries, which are the largest users of soil fumigants in California. With research and science projects, the beneficiaries are realized when the research journal is published and cited; this will be an ongoing process over many years.

Lessons Learned

The project staff believes that team work and multidisciplinary expertise to collect scientific data to be used by growers and regulatory agencies was the key requirement to complete this project. The amount of research and work put into this was overwhelming, and without the collective team and its efforts, this would have been very difficult.

Additional Information

Co-PD of this project discussed the research findings to several scientists, faculty, students and growers in Soil Science Society of America International Annual Meeting in November 2-5, 2014 in Long Beach, California:

Dangi, S.R., Hanson, B.D. and J. Gerik. 2014. Recovery of soil microbial communities after fumigation with time. Phytopathology 104 (Suppl. 3): S3.30.

Dangi, S.R., R. Tirado-Corbala, B.D. Hanson and J.S. Gerik. Effects of farm management practices on soil microbial communities overtime. Biology and Fertility of Soils (In Preparation).

Dangi, S.R., R. Tirado-Corbala, B.D. Hanson and J.S. Gerik. Effect of long-term continuous application of fumigants on soil microbial communities. Soil Biology and Biochemistry (In Preparation).

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 44	Project Title: Performance-based Conservation Incentives for Berries	
Grant Recipient: Resource Conservation District of Santa Cruz County (RCDSCC)	**Grant Agreement No.:** SCB12044	**Date Submitted:** December 2015
Recipient Contact: Sacha Lozano	**Telephone:** (831) 464-2950 ext 11	**Email:** slozano@rcdsantacruz.org

Project Summary

The Pajaro and lower Salinas Valleys on California's central coast support a multi-billion vegetable and berry specialty crop industry. Cool coastal climate and long growing season allow multiple crop cycles and high productivity. However, threats related to water supply and water quality challenge the long-term viability and competitiveness of this industry. The region suffers from persistent groundwater overdraft and seawater intrusion, which have been aggravated by recent drought conditions. Regional water quality regulations on the other hand, demand increasingly strict accountability and higher efficiency of nitrogen use on specialty crops. This is highly contentious and the industry fears that unreasonable and/or costly compliance requirements can pose economic burden or risk of yield loss. In response to these challenges, this project (and the partnerships behind it) addressed a need to support the industry in finding more proactive solutions. The Performance-based Incentives for Conservation in Agriculture (PICA) program was conceived as a long-term initiative to develop positive incentives for growers to achieve environmental performance targets, and facilitate voluntary adoption of metrics, monitoring, and decision support tools (through technical assistance and technology) to inform irrigation and nutrient management, improve water conservation and reduce nitrogen discharge from farms.

The long-term goals for this program included: Improving conservation outcomes for water quality and quantity in the Pajaro Valley, while stimulating innovation through standardized metrics and conservation incentives; creating new economic opportunities for farmers, while allowing them flexibility of new approaches in meeting nutrient and aquifer impact targets; and creating a replicable model to be used in other geographic areas, specialty crops, and to be adapted by agricultural policy makers and the private sector.

This project focuses on improving the competitiveness of California specialty crop farms by enhancing their environmental performance as it relates to reducing groundwater overdraft and nitrogen contamination to surface waters and aquifers. Agricultural communities on the central coast continue to struggle with over tapped water supplies, seawater intrusion, impaired water quality, and the potential need to invest in costly infrastructure to create sustainable water supplies. The persistent degradation of water resources and recent drought conditions pose a critical threat to the viability of agriculture in this region. Recognizing the urgency of these issues, leaders within the agriculture industry along with partners in resource conservation are actively working to develop innovative, more cost-effective means of achieving measurable improvements to environmental performance at farm and watershed scales.

The Pajaro and Salinas River watersheds in Monterey and Santa Cruz counties are an ideal incubator for developing and implementing incentives for measured environmental performance on specialty crop farms. These two watersheds host exceptionally high value production agriculture, globally significant natural resources, persistent water resource concerns, and a foundation of innovative industry leadership and collaboration. The severity of water supply and water quality issues in this region have led to heightened regulatory scrutiny, creating on the one hand a challenge for growers and water management agencies, and an opportunity for new incentives that could provide regulatory compliance alternatives on the other.

The PICA project has been able to leverage a broad public-private partnership with active participation of the berry industry growers, conservation agencies, academic researchers and field experts. Project partners include the Resource Conservation District of Santa Cruz County (RCDSCC), Sustainable Conservation (SusCon), Driscoll Berry Associates (Driscoll's), the Natural Resources Conservation Service (NRCS), University of California Cooperative Extension, Central Coast Water Quality Preservation Inc., the RCD of Monterey County, SureHarvest, the Stewardship Index for Specialty Crops (SISC), and private growers representing six different shipping companies.

This partnership is developing an innovative model for measuring, verifying and rewarding environmental performance on specialty crop farms. Conservation incentive programs have traditionally been "practice-based" rewarding adoption of pre-defined conservation practices by offsetting implementation costs. While the environmental benefits of these practices is generally understood, rewards are rarely linked to measured improvements resulting from the implementation and management of these practices. Alternatively, performance-based incentives focus on rewarding measurable outcomes. Focusing on outcomes rather than practices affords growers greater flexibility in how they achieve conservation goals, thereby encouraging innovation of more cost-effective means of environmental stewardship.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

This project developed and tested metrics and monitoring protocols for central coast strawberry farms to quantify the environmental performance on three indicators related to water supply and water quality: Irrigation water use efficiency relative to crop demand, nitrogen and sediment discharge through surface runoff, and total crop nitrogen mass balance (input/uptake) as an indicator of nitrogen use efficiency and potential Nitrogen (N) leaching below the root zone. The project collected baseline data on the three performance metrics on sixteen farms and created a 'template' that can be adapted to other specialty crops and other regions. In the process of developing these metrics, the project reviewed and adapted a logic framework for performance goals, targets and incentive allocation that had been drafted with previous funding from the NRCS-CIG program. Through this project, the RCDSCC built important partnerships with various industry groups to better serve specialty crop farmers, further advance the "measure to manage" approach, and develop concepts for performance-based incentives to reward water conservation and water quality protection.

This project also assisted with the development and pilot testing of University of California Cooperative Extension's (UCCE) on-line decision support tool CropManage application (CM). CM application provides real-time crop-specific recommendations on irrigation scheduling and nitrogen application based on weather data (evapotranspiration), canopy cover, current soil nitrogen levels, and water/nitrogen uptake models derived from years of research.

Throughout the grant period, project staff collected and analyzed data from sixteen strawberry farms in the Pajaro Valley and Elkhorn Slough watersheds. Data collection and analysis was completed for nine farms during the full 2013-2014 crop season. Data collection and analysis is currently in progress on seven additional farms for the 2014-2015 crop, and it will be completed with additional funding beyond the end of this grant. Data collected was used to evaluate performance on water use efficiency and nitrogen loss metrics according to the logic framework presented above. As part of the water use efficiency monitoring protocol, the project staff collected monthly irrigation water use records from participating farms, and used CM to estimate site-specific evapotranspiration (ETc) values (derived from canopy cover and ET data from local California Irrigation Management Information System –CIMIS- weather stations). As part of the nitrogen use efficiency monitoring protocol (to estimate potential nitrate leaching), the project staff collected the following data at each participating farm: Monthly fertilizer application records, soil nitrate quick tests to estimate soil nitrogen content in the top two feet (i.e. at and slightly below root zone) during three different stages of the crop cycle, nitrogen concentration in irrigation water, total crop yield, and collected twelve whole plants per field to conduct plant tissue analysis in the laboratory and measure nitrogen uptake. Monthly irrigation and fertilizer application records as well as soil nitrate concentration data were manually entered into CM.

Table 1 summarizes the anonymous comparison of water and nitrogen use efficiency calculations among nine ranches participating in this project during the 2013-2014 strawberry crop. Ranch 4 was not included in the analysis (even though it was part of the initial group) because it significantly differed from the rest in terms of scale, type of operation and water sources. Incomplete and/or inconsistent data prevented completion of the nitrogen use efficiency analysis on three ranches (two of them did not provide complete fertilizer records and one of them did not report crop yield). In addition, three ranches had incomplete water use records during the plant establishment phase, thus preventing calculation of water use efficiency for the full season on those ranches.

Aggregate Anonymous Report - For peer comparison and incentives eligibility

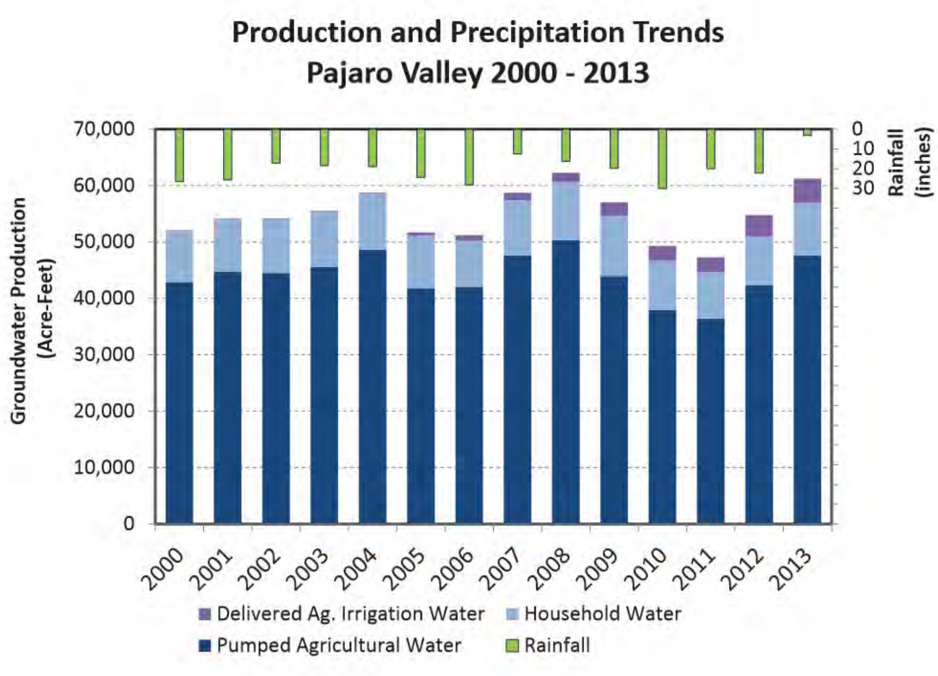
	Water Use Efficiency		**Nitrogen Use Efficiency ***	**Yield**	**# irrigated Acres**	**Crop type**
2013 - 2014 Season	Water applied/ETc Full season (Nov-Oct)	Water applied/ETc Production (Mar-Oct)	Seasonal N net inputs/Crop N uptake	(Lbs fruit/acre) Full Season		
Ranch ID						
1	incomplete data	1.26	1.48	56,926.32	19	Conventional
2	1.46	1.20	incomplete data	36,000.00	18	Organic
3	1.69	1.30	1.59	72,400.00	65	Conventional
4	not analyzed	not analyzed	not analyzed	not analyzed	0.2	Organic
5	incomplete data	0.93	1.68	69,149.51	45	Conventional
6	2.09	1.23	0.99	61,310.00	28.9	Conventional
7	**1.07**	**0.89**	**3.62**	**29,971.00**	**21.5**	Organic
8	0.97	0.82	incomplete data	24,000.00	11	Organic
9	1.78	1.44	0.13	61,913.04	23	Conventional
10	incomplete data	0.79	incomplete data	nd	12	Conventional
Average	**1.52**	**1.12**	**1.58**	**51,458.73**	**24.36**	
Min-Max Range	**0.95 - 2.09**	**0.79 - 1.44**	**0.13 - 3.62**	**24,000 - 72,400**	**11 - 65**	

Table 1. Water and nitrogen use efficiency ratios on nine strawberry ranches in lower Pajaro and Elkhorn Slough watersheds, California Central Coast.

Besides the aggregate anonymous comparison, each participating grower received a detailed confidential report with all the data collected on his farm for each performance metric, and a number of graphs for peer comparison purposes (indicating performance relative to others).

For the surface nitrogen and sediment runoff metric, the project team conducted intensive on-site monitoring on seven farms during the 2013-2014 winter (it was a dry year and most rain occurred between Jan-Mar). Flow rates and concentrations of nitrate and total suspended solids in surface runoff leaving farm fields were measured during two to three storm events per farm. Samples were collected at two to three different points on each farm and at least twice during each storm in order to estimate the amount of nitrate and sediment loss, and identify possible sources. While comprehensive, this method proved to be impractical for growers to adopt. In 2014-2015, the project staff developed and tested a low-cost storm runoff auto-sampler, in order to simplify data collection and improve data quality. The auto-sampler consisted of a hand-made wooden weir, installed at the bottom of a lined drainage channel (ditch) collecting water from one or more blocks. At the base of the weir, a hole was dug out on the channel to install three self-sealing Nalgene™ water sampling bottles. The bottles were placed at different heights to collect samples during early, mid and peak flows. At the back of the weir a water level data logger (Hobo) was also installed to track changes in water level every ten minutes, and estimate total volume discharged during the storm based on the weir dimensions.

The automated runoff sampling system will continue to be developed and tested beyond the end of this grant and it is expected to serve the following purposes: Streamline sampling logistics and reduce barriers for growers to adopt this metric as part of their annual monitoring, and improve consistency and accuracy of the data, by ensuring collection of samples during three representative points in the storm hydrograph (particularly during peak flows often occurring at night), and better tracking of changes in flow and total volume discharged during individual storms.



The project staff collected baseline data on ambient watershed and aquifer conditions from the Pajaro Valley Water Management Agency (PVWMA). PVWMA developed a five-year baseline for total groundwater pumping within the agency's jurisdiction. This baseline is an average of 54,947 AF per year for 2006-2010, which includes wet, dry and normal years (44,000 of those represent agricultural use).

RCDSCC staff, in partnership with Natural Resource Conservation Service (NRCS) regional agronomist, planned and delivered two Nutrient Budgeting workshops for participating specialty crop growers as part of the educational and technical support component of this project. These workshops introduced these growers to concepts and a practical tools (worksheets) developed by NRCS for planning annual N-P-K budgets for specialty crops.

The project staff provided individual hands-on trainings to ten participating specialty crop farmers on methodology and applications of the Soil Nitrate Quick Test (SNQT). The SNQT is a validated tool that allows growers to conduct rapid assessments of available nitrate in their soil, which they can use to decide when and how much nitrogen they need to apply in order to meet plant needs (depending on what part of the growing cycle they are in). By training growers how to estimate soil nitrate using the SNQT, the project staff simultaneously engaged them in the collection of data to estimate nitrogen use efficiency as an indirect measurement for leaching, integrating useful data collection to the education and capacity building aspect of the project. Each participating grower received a kit of materials and supplies necessary to conduct the SNQT, and the project staff provided individual follow up to participating growers to address questions and ensure their understanding and effective use of these tools.

Through this project, University of California Cooperative Extension (UCCE) partners completed the programming upgrade for the online decision-support tool CM to be used for irrigation and nitrogen input scheduling in strawberry production. UCCE hosted two annual CM trainings for growers in 2014 and 2015. Two participating growers attended these trainings. RCDSCC staff followed up individually and provided one-on-one trainings to other participating growers. The project staff continues to train and build capacity among participating growers to facilitate adoption of CM as a management and recordkeeping tool.

In the beginning of the project, the RCDSCC surveyed growers to identify which incentives would be most valued and motivate growers to measure and achieve environmental performance on farms. The top incentives identified by growers included: having data to inform management, knowing where you stand relative to peers, regulatory relief, offset costs of implementing practices, and market incentives (such as preferential specialty crop pricing or market access).

RCDSCC staff and partners at Sustainable Conservation, with guidance from the project's strategic advisors, then assessed opportunities and developed concepts for incentives to reward growers for achieving performance targets.

Specialty crop growers participating in this project were most interested in tracking environmental performance in order to have data to inform and improve their water and nutrient use decisions. The metrics, monitoring protocols, and reporting formats were developed to meet this key objective. Growers were also motivated to know where they stand relative to their peers in terms of water and nutrient use efficiency, evidence that industry competition can be a key motivator for changing practices. Performance reports generated by the project included this anonymous peer to peer comparison to illuminate to each grower areas for improvement and areas where they outperform their peers.

Regulatory relief (or alternative regulatory compliance reporting) was a key incentive that growers identified for monitoring on-farm environmental performance. In particular, growers on the central coast are subject to intensive reporting requirements to comply with the Agricultural Order administered by the central coast

Regional Water Quality Control Board. Since the early stages of this project, RCDSCC staff engaged in regional discussions with the agricultural industry, conservation partners, and the Regional Water Quality Control Board to identify opportunities for rewarding growers who are tracking their environmental performance through reduced regulatory reporting burden. The Central Coast Regional Water Quality Control Board postponed discussions to renew the "Ag Order" for another year, which delays when fully functioning alternative regulatory compliance reporting could be in place, and leaves open questions about what that incentive could look like due to uncertainties about what will be required of growers under the next iteration of the "Ag Order." The monitoring protocols, reporting templates, and partnerships that have been established through this project will serve as a model that the RCDSCC, industry partners, and other stakeholders can refer to when discussing renewing the "Ag Order."

Pajaro Valley Water Management Agency (PVWMA) is in charge of managing and sustaining groundwater resources in the Pajaro Valley. The Agency meters agricultural wells and collects fees which are invested in a suite of projects outlined in the Basin Management Plan which aims to halt seawater intrusion. Among those projects, is a water conservation program, which can be a source of assistance and incentives for growers to achieve conservation targets. Achieving conservation targets in the valley is essential for avoiding future regulation, restrictions, or fee increases that would be necessary for more costly alternative projects to bring the aquifer into balance. RCDSCC staff coordinated with the PVWMA to integrate PICA performance metrics and monitoring methods into Pajaro Valley basin wide tracking of water conservation outcomes. This integration can lead to increased opportunities for growers documenting water use efficiency performance to access future incentives provided by the PVWMA, for example access to the water conservation program.

Goals of this project were to develop incentives and improve applicability and access to farm nutrient and water management advisory tools for berry growers to demonstrate environmental performance and meet conservation targets; and to adopt new practices and farm management information tools and strategies. Growers acknowledged that tracking environmental performance on their farms can require implementation of new tools and technologies, such as flow meters to measure water use or soil moisture sensors to track plant water needs. And when performance tracking reveals inefficiencies, the changes growers have to make to improve their efficiency can also be costly. For these reasons, growers continue to seek financial incentives to offset implementation costs. RCDSCC staff worked with participating growers to access available financial incentives, including cost share available through this grant, through the USDA Natural Resources Conservation Service, and through California Department of Food and Agriculture's State Water and Energy Enhancement Program.

The PICA partners worked to strengthen partnerships to link on-farm performance monitoring. RCDSCC staff and Sustainable Conservation built a partnership with the Stewardship Index for Specialty Crops (SISC) which is working with major retailers and buyers of specialty crop vegetables grown in Monterey and Santa Cruz counties to create demand and value for the type of on-farm performance monitoring that growers are implementing under this project. RCDSCC staff are coordinating with staff of the RCD of Monterey County, the NRCS, Sustainable Conservation, and SISC to integrate PICA monitoring protocols and reporting templates into the SISC pilot. This partnership will continue beyond the grant period, and holds huge potential for expanding the scale and scope of PICA performance monitoring to new specialty crops and regions. RCDSCC staff worked with partners to develop concept proposals for expanding the current PICA program to specialty crop vegetables and to expand the concept to other environmental performance indicators including soil health and managed aquifer recharge.

While participating growers did not identify access to loans as a key incentive for environmental performance monitoring, opportunities and partnerships to explore these incentives emerged over the course of the grant period. RCDSCC and Sustainable Conservation staff worked with staff from California FarmLink to develop a proposal for linking preferred loan rates and loan access to growers who demonstrate achievement of water use efficiency performance targets. California FarmLink is a community development financial institution certified by the Department of the Treasury, focused on linking farmers and ranchers with the land and capital they need to be successful. FarmLink has a strong commitment to supporting sustainable and organic farmers and ranchers, and helping all producers improve their environmental performance while achieving financial viability. Based on discussions with the PICA team, FarmLink has agreed to partner with the RCDSCC and Sustainable Conservation to develop a proposal for a loan product with incentive-based interest rates tied to environmental performance targets. Through this partnership with FarmLink, growers can use their performance data to demonstrate reduced risk to water scarcity as part of the underwriting process. RCDSCC staff will be working with FarmLink and Sustainable Conservation to further develop and seek financing to pilot this performance-based loan product beyond the grant period.

In collaboration with Sustainable Conservation, SureHarvest was contracted to conduct a program analysis and research a conceptual business framework for sustaining and expanding the PICA project. The purpose of this report was to better understand the costs and benefits of on-farm performance monitoring to better understand the economic case (incentive) to growers for tracking environmental performance. This report analyzed the costs of collecting on-farm environmental performance data (to the grower and to technical service providers like the RCD) and grower return on investment in terms of cost savings from reduced inputs, increased yields or pricing resulting from participating in PICA. Return on investments (ROIs) were determined for the most valuable crops in California coastal counties. Based on an assumption of 20,000 participating acres paying $9.90 per acre to collect performance information, a fifty acre strawberry ranch would show a positive financial ROI starting at around a 6.5% cost reduction. This level of water and nutrient use savings seems reasonable given the measured on-farm performance of participating growers to date. The outcomes of this report will help make the economic case to growers for tracking water and nutrient use efficiency. This report will also help inform the project partners in thinking about possible funding mechanisms for sustaining and expanding the program in the future.

Between 2013 and 2015, the project staff presented progress updates, results and lessons learned at various events and partner meetings, providing an overview of the PICA project to diverse specialty crop interested audiences including: Resource conservation agencies (federal, state and local), water managers, farmers, farm advisors, private consultants, academics and general public.

In the fall of 2013, the project staff gave updates on the PICA project to staff from California Department of Conservation (DOC), USDA and other organizations:

- Monterey Bay Conference on Water Quality, an event coordinated by NOAA's Monterey Bay National Marine Sanctuary (Feb 2014) (85-100 attendees)
- UCCE irrigation efficiency grower workshop (6/19/14) (40 attendees)
- Meeting with the University of California, Berkeley Diversified Farming Systems Group (7/25/14) (6 attendees)

- California Association of Resource Conservation Districts (CARCD) 69th Annual Conference (Nov 2014). (40-45 attendees)
- Meeting with project partners to present and discuss findings from the SureHarvest report (December 2014). (12 attendees)
- Field tour with CERES staff co-hosted by Driscoll's (February 2015). (12 attendees)
- Fourth California Climate and Agriculture (CalCAN) Summit (March 2015). (35 attendees)
- Monterey Bay Agricultural Water Quality Alliance (AWQA) (6/10/15) (10 attendees)
- NRCS national office, during two special tours focusing on regional initiatives and partnerships for water resource protection in the Pajaro and Salinas Valleys. (2013 and 2015) (50 attendees)

The metrics, monitoring protocols, decision support tools and incentive concepts developed in this project were specific to a subset of specialty crops on the central coast of California. Funds were exclusively used to enhance the competitiveness of California specialty crops.

Project contributors and collaborators included:
UCCE provided technical advice on water and nitrogen use efficiency metrics and monitoring protocols, and developed on-line decision support tool CM for scheduling and recordkeeping of irrigation and nitrogen applications. SusCon provided matching funds, advice on developing incentives, and facilitation of partnerships with the agriculture industry and SISC. Driscoll's provided individual ranch water use data for baseline and efficiency calculations, CM application trials, and technical advice. PVWMA provided baseline water use data at watershed scale (for the Pajaro Basin). Preservation Inc. gave advice to develop and revise surface runoff metrics and monitoring protocols. RCD of Monterey County provided technical advice and technical support in the field.

Goals and Outcomes Achieved

This project created a working logical framework to assess performance on water use, surface nitrate runoff and nitrate leaching to groundwater. The framework consists of a sequence of objectives, indicators, metrics, methods, and targets for each of the three parameters and it continues to be revised and updated.

The project established a monitoring and metrics working group, convened a Technical Advisory Committee to develop preliminary targets and monitoring methodologies for evaluating environmental performance in berries, and convened a Grower Advisory Committee to vet proposed targets and monitoring methods and to assess growers' preferred incentives.

Between 2013 and 2015, the project staff completed implementation (data collection and analysis) of the approved performance assessment framework for water and nutrient use efficiency (also referred to as the revised "logic framework") for the 2013-2014 strawberry crop on nine ranches in the Pajaro River and Elkhorn Slough watersheds. The project staff is currently collecting data on seven additional ranches for the 2014-2015 crop for a total of sixteen ranches. This exceeds the project target goal of fifteen ranches.

The project staff conducted bilingual field demonstrations and trainings on tools and management strategies to assist specialty crop growers in improving water use efficiency and nutrient management. The staff also coordinated with industry leaders and researchers engaged in evaluating the effectiveness of nitrate management practices that could support PICA participants in achieving performance targets to ensure consistent delivery and integration of services across the region.

One of the goals of this project was developing incentives. The project staff has collaborated with a number of agriculture industry groups to inform the development of scalable metrics which wholesale buyers can use to develop sustainability standards to determine market access. The project staff advanced efforts to develop regulatory relief/certainty incentives by participating in the regional Water Quality Collaborative effort. Although the Central Coast Regional Water Quality Control Board delayed the process for developing the next "Ag Order," the project staff continued to build partnerships to integrate performance metrics into future proposals for alternative regulatory compliance reporting. The project staff formalized a partnership with FarmLink to develop a proposal for a new performance-based loan product to provide preferential rates and loan access to growers who demonstrate high water use efficiency. RCDSCC staff worked with PICA participating growers to help them access existing cost-share incentives to implement practices to improve performance relative to water and nutrient use efficiency.

In terms of improving applicability and access to farm nutrient and water management advisory tools, the project staff updated the CM application for use in strawberry production and trained six participating growers to use the tool. A Nitrogen budgeting tool (worksheet) developed by NRCS's regional agronomist was made available in Spanish and trainings on nutrient budgeting and use of this tool was provided to participating growers. Soil Nitrate Quick Test (SNQT) trainings and kits were delivered to participating growers contributing to inform fertilizer management decisions. A total of sixteen ranches adopted new practices and farm management information tools and strategies during the PICA project, exceeding the goal of fifteen ranches. In collaboration with Sustainable Conservation, SureHarvest was contracted to develop an assessment of economic impacts for participating growers.

Long-term project outcomes included: Creating site-specific baseline data on sixteen strawberry farms, building capacity among growers for adoption of tools and monitoring protocols to track numbers necessary to evaluate performance changes over time, and developing partnerships and concepts for performance-based incentives and proposals to advance these incentive concepts beyond the grant period. All these were achieved.

Project accomplishments are outlined below:

Goal	Accomplishments	Comments
Goal 1: Improve conservation outcomes for water quality and quantity for the berry industry in the Pajaro Valley. Performance Measures: 1A) A minimum of 90% of participating farmers will report achieving targets for nutrient reduction and; 1B) At least 90% of	Worked with sixteen berry ranches to improve water quality and quantity. Eleven out of sixteen ranches (68.7%) achieved a water use efficiency of 120% ETc or less. Thirteen ranches (81.25%) achieved a 130% or lower water use efficiency. This is considered	The project's technical and strategic advisors recommended that firm performance targets not be established under this project. Rather, the project should collect baseline performance data and begin to identify outliers. Performance targets should

participating farmers will report achieving targets for water conservation.	highly efficient within the industry. Fifteen out of sixteen ranches (93.7%) achieved a nutrient use efficiency of 170% (input/uptake ratio) or less. The industry does not currently have a benchmark or target set for this metric.	be established by each incentive provider.
Goal 2: Develop incentives and improve applicability and access to farm nutrient and water management advisory tools, for berry growers to demonstrate environmental performance and meet conservation targets. Performance Measure: 2A) At least fifteen ranches will adopt new practices and farm management information tools and strategies and; 2B) At least 90% of participating farmers will collect information to assess net economic impacts after implementing such practices and management tools.	Sixteen ranches adopted new practices and farm management tools and strategies. Staff collected information on costs of implementing performance monitoring on 100% of participating ranches. Benefits were projected based on an assumption of future program expansion (which would spread some costs more broadly), which found a positive ROI starting at around a 6.5% cost reduction (i.e. when a grower uses 6.5% less water or fertilizer, the costs of monitoring efficiency are offset).	Benefits such as improved product quality or shelf life resulting from more closely matching water and nutrient applications to crop demand were not considered, but could have a significant positive impact on the economic benefits of implementing these practices and management tools.

The average water use efficiency measured as (water applied/ETc)x100, for nine participating farms in the 2013-2014 crop (111%), was 30% higher than baseline efficiency (140%) documented from previous trials and monitoring within the industry and UC Cooperative Extension. This represents a significant achievement, which is partly due to the adoption of monitoring practices and decision support tools through this project.

Beneficiaries

This project directly served conventional and organic strawberry growers in the Pajaro Valley and Elkhorn Slough watersheds. The metrics, monitoring protocols, tools, and incentives are immediately transferable to other strawberry growers within these regions and throughout the state of California. Vegetable growers in Monterey and Santa Cruz Counties expressed interest in the PICA model, and through a current partnership with SISC, Sustainable Conservation, and the RCD of Monterey County the RCDSCC is working to adapt and transfer these tools to lettuce growers.

Sixteen strawberry ranches in Pajaro Valley and Elkhorn Slough watersheds directly benefit from this project. Four-hundred strawberry growers in the state of California benefitted from upgrading CropManage to include strawberry production tools. Six lettuce growers also benefit through partnership and expansion with SISC and RCDMC. If transferred statewide, the project's impacts can potentially benefit specialty crop producers more broadly.

Lessons Learned

Grower's interest in anonymous peer-to-peer comparisons (of input use efficiency and yield) is a powerful driver for adopting monitoring practices, recordkeeping and performance reporting. Access to this kind of information is in itself a strong incentive.

Specialty crop growers on the central coast tend to be generous with staff time and willing to share sensitive management information when confidentiality is adequately protected, they are not threatened by regulatory enforcement, and they see value in the applicability of monitoring and data collection. This attitude is a valuable asset that facilitates the development of a knowledge base to improve the competitiveness and environmental performance of this industry.

Baseline data developed and acquired through this project demonstrates that the strawberry industry is actively improving its input use efficiency (water and nitrogen) through a variety of efforts including adoption of technology and cultural practices, and in many cases input use is very well aligned with crop demand. Growers who can already demonstrate high levels of efficiency should be able to access incentives to reward their performance. The monitoring and reporting developed through this project can help identify 'outliers' or growers with more room for improvement and focus technical assistance efforts to guide those growers.

Data collection needs to be further automated and simplified in order to make monitoring feedback to growers more efficient and timely (for both management and reporting purposes). At the same time, technical assistance, interpretation and capacity building (training) on the use of recordkeeping and decision support tools remain critical aspects of the program, and must accompany the entire process to ensure data quality control and maximize grower's practical use of the information.

Automation of data collection (e.g. flowmeters, data loggers, telemetry, CM application) is relatively straightforward and inexpensive, but growers need to be convinced of its value, and it should be regarded as only one more tool within their decision making process (not a replacement for it).

CM application still lacks the capability of automatically importing data from other platforms (e.g. flowmeter data logging software). UCCE is currently working to develop this capability, but until that happens, all data must be manually entered to the software, which creates significant delays and potentially detracts adoption of this tool.

Developing a practical and useful metric (and monitoring protocol) for surface nitrogen and sediment runoff remains a challenge. The RCDs of Santa Cruz and Monterey Counties will continue to collaborate on this aspect of the program beyond the end of this project.

The project staff developed broader than expected partnerships within the specialty crop industry and engaged into a much higher level conversation about performance-base metrics and incentives, providing practical insights and leadership to streamline metrics, monitoring protocols, technical assistance and support tools for growers.

The project staff accessed an unexpected opportunity to inform the next iteration of local water quality regulation related to nitrogen discharge (Central Coast Regional Water Quality Control Board's Ag Order), rather than simply develop alternative reporting to comply with existing regulations. Findings from this project can help to frame and define compliance requirements and/or alternative reporting options in the new update.

Through this grant project, the project staff acquired three flowmeters with automated data logging capabilities, which will continue to be used to serve growers and offer capacity building through a loaner program, to encourage adoption of performance monitoring and reporting.

USDA Project No.: 45	Project Title: Improving irrigation efficiency within the Paso Robles Groundwater Basin	
Grant Recipient: University of California Cooperative Extension, San Luis Obispo	**Grant Agreement No.:** SCB12045	**Date Submitted:** December 2015
Recipient Contact: Mark Battany	**Telephone:** 805-781-5948	**Email:** mcbattany@ucanr.edu

Project Summary

The over 30,000 acres of wine grapes that overlay the Paso Robles Groundwater Basin rely upon it exclusively for irrigation. There is no other water source in the region. The Basin also supports other water users, primarily municipal, rural residential, and irrigation of minor crops. The irrigation of wine grapes is the largest component of the overall pumping of water from the Basin. The wine grape industry and associate winery and tourism activities is the overwhelmingly dominant economic activity in the region, as such the reliability of the water supply to continue producing wine grapes is critically important to the regional economy.

However, there have been serious concerns about over-usage of water from the Basin due to over development of all uses but in particular to the rapid growth of vineyard acreage in the past two decades. Groundwater levels have been observed to be declining in many parts of the Basin, indicating that pumping in excess of the sustainable yield may be occurring. The California Department of Water Resources considers the Basin to be of “High” priority with regards to needing to implement sustainable groundwater management practices.

Given the large role that vineyard irrigation has in the Basin, it is clear that part of the solution of attaining sustainable Basin management will be to reduce as much as possible the irrigation demand of overlying vineyards. Wine grape vineyards are already very efficient with water use as compared to most crops; drip irrigation and deficit irrigation practices are commonly employed. However, achieving even more efficient use may be required in the region to maintain overall pumping within the sustainable yield (water output) of the Basin. Thus this project had as its focus the development of new information specific to the Paso Robles Groundwater Basin area that could help wine grape growers in the area achieve the most efficient irrigation management possible, with the goal of potentially reducing their usage of water and thus reducing impacts upon the Basin.

It would have been difficult to imagine this project having been timelier, with the onset of the extended drought coinciding with the project. The drought conditions have unfortunately greatly accelerated and exacerbated the problems with the Basin, as irrigation water use needs to increase in dry years and less rainfall recharges the groundwater supply. Thus concerns about water supply from the Basin have been the highest priority issue for all parties that utilize the Basin for their water supply, including vineyards, rural residential and municipalities. This project has served a very critical and timely role by making key data available in the ongoing assessment of the condition and characteristics of the Groundwater Basin

This project did not build upon a prior Specialty Crop Block Grant Program (SCBGP), however it continues to work towards the goal of water conservation in vineyard production of a previously funded 2011 SCBGP

Project 15: *An assessment of springtime temperature inversion conditions and the usefulness of wind machines for frost protection in California coastal wine grape regions.*

Project Approach

An initial task of this project was to collect demonstration data from various irrigation management tools, as teaching information in extension efforts. At one site, a comprehensive set of measurements including soil moisture from two types of sensors, irrigation system operation, reference evapotranspiration from an atmometer, leaf water potential and stomatal conductance (both measures of vine water stress), and the canopy shaded area to calculate the crop coefficient. At a second demonstration site, a full 'Surface Renewal' weather station was operated to measure real-time evapotranspiration data from a vineyard over three seasons. This demonstration data was used repeatedly in extension efforts as intended.

The Paso Robles Groundwater Basin is recharged primarily with rainfall, and the lack of adequate rain gauges in the region hindered understanding of recharge. This was addressed by installing 18 weather stations throughout the Basin and watershed to collect rainfall. To add value to these sites, soil moisture sensors were installed at 12 locations (the remaining six require the hardware that is currently used in the 'Surface Renewal' research described below). The soil moisture data will provide a key type of information that has been lacking in this area: at what date in the spring does the soil moisture content reach its maximum? By knowing this, growers will be able to time the termination of the cover crop growth to maximize soil moisture content, and thus reduce the need for later irrigation. Reducing excessive and unnecessary water consumption by cover crops in the spring is one key strategy for reducing overall irrigation applications.

The project successfully completed an evaluation of the irrigation applications made at 84 commercial vineyard sites over a four-year period. This project had been initiated in 2009 with local industry support, and measurements were made over the 2010-2013 seasons inclusively, using custom-built irrigation monitoring devices installed at each of the 84 sites. The research assistant processed a very large data set to produce the summary data on annual water usage in vineyards and how this usage varied depending upon previous winter rainfall. This effort resulted in heretofore unobtainable information regarding how area vineyards used water; this was a critical component of the extensive update of the Paso Robles Groundwater Basin Model, carried out by Geosciences and Todd Engineers in 2014. Having access to this data set allowed the modelers to have the most robust information available in constructing and calibrating their complex model. Previous efforts to model the Groundwater Basin were hampered by not having accurate vineyard water use data, and this was a recognized shortcoming in the subsequent peer reviews. This updated more accurate model in turn has been a critical tool for understanding the current state of the Basin, and as importantly what could happen to the Basin into the future under various possible growth scenarios. The results of the comprehensive irrigation study were critical to making this updated and more accurate tool a reality.

During the 2013 and 2014 summer growing seasons, a set of 18 water-based evaporation gauges (atmometers) were used to measure the daily reference evapotranspiration rate throughout the Paso Robles Groundwater Basin area. Measurements were made within irrigated vineyards. The goal of this work was to compare these measurements to estimates of the reference evapotranspiration as provided by the California Dept. of Water Resources 'Spatial CIMIS' program. This relatively new program has the potential to provide very useful reference evapotranspiration data in areas not served adequately with weather stations, but it needs to be verified against on-the-ground measures to determine how accurate the estimates are in areas of non-uniform terrain such as the Paso Robles area. This data set has been fully collected and will be evaluated in the near future to provide growers with a means to determine how appropriate the Spatial CIMIS tool may be for irrigation management at their sites.

This project conducted one of the most detailed evaluations of the 'Surface Renewal' method of estimating real-time crop transpiration in vineyards to date, in collaboration with United States Department of Agriculture (USDA), University of California (UC) scientists, and the J. Lohr Winery staff. Ten of the newly commercialized 'Surface Renewal' stations manufactured by Tule Technologies have been operated since early 2014 in ten individual vineyard blocks farmed by the J. Lohr Winery. This project is being continued in the 2015 growing seasons (this second year of research is being supported by the J. Lohr Winery). Having two full seasons of measurements will be important for the project team to be able to conduct valued research to publish the results of this study.

The comparison data that the team of collaborators is collecting to evaluate the 'Surface Renewal' measurements is very comprehensive; it includes irrigation system sensors in each vineyard, soil moisture sensors at four depths at each vineyard, weekly measurements of leaf water potential, and weekly measurements of the canopy shaded area (from which the irrigation crop coefficient is calculated). Additionally the commercial aerial imagery firm Terravion is providing a variety of digital aerial imagery throughout the season at each of the ten sites.

Additionally, four custom weather stations were installed throughout the ten test sites to provide nearby reference evapotranspiration data; this is fundamental to test the 'Surface Renewal' measurements. Each weather station has a standard suite of sensors to calculate the reference evapotranspiration with the Penman-Monteith equation, and also have a modified water-based evaporation gauge that provides hourly water-based reference evapotranspiration data. Both of these are used to compare to the 'Surface Renewal' measurements, and also serve as a direct comparison of the two methods of calculating reference evapotranspiration; this latter comparison will help validate the previous atmometer measurements made throughout the Groundwater Basin area. Lastly, at two of the ten sites, weather stations are measuring the temperature of the leaf canopy from overhead towers; the canopy temperature is another tool that indicates relative vine water stress, and will also be used to evaluate the 'Surface Renewal' data. Due to this second year of measurements being conducted in 2015, the final evaluation of the data will not occur until after harvest in October 2015. The final data from our Surface Renewal experiment was collected in September 2015; thus the project team will be processing the data from this and the other experiments of this project. The goal is to have summary information of the results shared with the local vineyard industry in a regional seminar before the spring of 2016, so that the growers can apply the information to management in 2016 and beyond. Publications of more detailed articles will follow as the information is processed, with articles submitted to journals such as Irrigation Science and California Agriculture. Summary articles will also be written on the Grape Notes Blog, and also a direct extension tool to reach the local vineyard industry in spring of 2016.

A variety of extension efforts stemmed from this project. One example is the modification of an online irrigation calculator that was originally developed for Sonoma County, for use on the Central Coast by incorporating local reference evapotranspiration data. The principal investigator gave presentations on the data and concepts of this project at numerous University extension meetings in San Luis Obispo County, elsewhere in California, and nationally. Examples include three extension seminars in the Paso Robles area in 2013 and 2014 reaching over 400 attendees; a presentation titled "Managing vineyards with limited water" at the American Society for Enology and Viticulture's Annual Conference in June 2014, and a conference at

UC Davis in February 2015 on how changing water regulations would impact vineyard irrigation. Total attendees at these meetings have exceeded 1,000 people, thus information about this project's aims and outcomes have been well disseminated amongst the vineyard industry in California.

The goal of producing a text of vineyard irrigation management as an outcome of this project is being addressed by the creation of a UC Wine Grape Production Manual; this is a group project amongst the Viticulture Farm Advisors with the UC Cooperative Extension. The demonstration data collected in this project will create key figures in the manual.

The Paso Robles Groundwater Basin supplies water to both municipal and agricultural users. The dominant irrigated crop utilizing the Basin is wine grapes (more than 51%), and the shift from remaining acres of non-specialty crops (alfalfa, hay, pasture) to wine grapes is happening fairly quickly for economic reasons. The overwhelming majority of the crop value is generated by wine grapes, and with the economic multiplier effect generated by the associated winery tourism industry, the benefit of this project will be realized by the wine grape industry. All grants funds were spent only on the enhancement of specialty crops.

This project benefitted from extensive collaboration of the local wine grape industry by allowing sensitive measurements to be collected on their properties. Growers facing forced allocations and restrictions of future water use and fearing a court adjudication of water rights have every reason to be hesitant in allowing any public research of water usage to be conducted on their property. The extensive cooperation of the commercial industry available to assist this project attain its goals attests to the importance that these growers place on the information generated as well as their faith that the information will be used for the greater good and understanding of all.

Goals and Outcomes Achieved

All of the work conducted in this project was intended to enable local wine grape growers to manage irrigation as efficiently as possible with the intention of safeguarding the common water supply of the Paso Robles Groundwater Basin.

The current usage of irrigation was quantified in detail with the monitoring project at 84 sites. This monitoring revealed that average water application was about 1 ft. on average per year, somewhat less than the previous estimate of 1.25 ft. per year. The monitoring revealed a wide variability in water use, with some applying more than double the average amount; thus this indicates there are savings to be achieved by providing the heavy water users with tools and information to decrease use. The downside is the same tools and information may indicate to the extremely low water users (those applying less than half of the average) they need to increase irrigation to produce a more economically viable crop.

The demonstration of the more common irrigation tools such as soil moisture monitoring and plant water stress monitoring provided teaching tools for growers to understand how to ensure that they are optimizing water applications and minimizing waste.

The detailed analysis of the 'Surface Renewal' method will provide key data to indicate how effective and accurate this method is in providing real-time vineyard water consumption and vine water stress information, that growers can in turn use to manage irrigation more efficiently. A key advantage of this tool is that it provides real-time data, which can empower a grower to walk a finer line with reducing irrigation by having the confidence that the data will indicate if conditions have become too stressed before a serious problem occurs. The commercial supplier of this equipment has seen rapid adoption by many specialty crop sectors in California over the past year, primarily wine grape vineyards; this is in part due to ongoing presentations about the potential utility of the method for managing irrigation more efficiently.

The longer term operation of the local weather stations to collect more detailed rainfall information will help inform growers about the amount of irrigation that they can expect to apply the following season. An additional important outcome of the irrigation monitoring project was to develop a relationship between how much rainfall fell in the winter and how much irrigation was applied the following season; this simple but important relationship will allow growers to better plan for irrigation and potentially avoid over-irrigation in wetter-than-average years.

The operation of the soil moisture sensor plots at the weather stations will generate patterns of soil moisture extraction by cover crops over time, thus identifying the date in the late winter or early spring when the soil moisture content reaches its peak, prior to being consumed by the cover crop. This key date will be the optimum date to stop cover crop growth, to thus conserve soil moisture for later use by the vines; this type of active management of cover crops based on soil moisture data will enable growers to extract more benefit from rainfall and thus reduce irrigation extractions.

The recent groundwater legislation from the state mandates that high-priority groundwater basins such as the Paso Robles Groundwater Basin create groundwater management agencies (districts) to actively manage and safeguard the Basin by 2017. This as-yet uncreated district will need accurate vineyard water use data in order to carry out this mission. The monitoring study data will be one of the most important pieces of information available to this new district as it implements active management of pumping. The data provides guidance on how much water needs to be allocated to vineyards, and how this allocation needs to be adjusted from one year to the next based on the previous winter's rainfall. The new district would have needed many years of study to generate this data if it didn't exist as a result of this project; this will save immensely valuable time for the new district to begin implementing meaningful and effective groundwater management once it is created; this will in turn help ensure the sustainability of the groundwater resource for all users into the future.

All of the outcomes of this project are long term, and are described above.

The actual accomplishments compared to the goals of this project have been largely met, with some delays in final processing of data (explanation provided in the "Lessons Learned" section below). Thus final data analysis and publication/dissemination of the data measured in this extensive project will occur beyond the project end date.

The goal of conducting one season of detailed evaluation of the 'Surface Renewal' method at ten sites was extended with a second season, beyond the end of the project; this was made possible by support from the vineyard cooperator. This too will shift the final data analysis and publication until after harvest in January 2016.

The results of the monitoring project at 84 sites provided clear and robust baseline water use data for area vineyards. This data will be the benchmark for comparison over time as additional water-saving practices are implemented into the future. The as-of-now, uncreated water district will be required to measure vineyard water usage as part of its management of the Basin; this ongoing water usage data will then provide the long-term comparison to assess how much water usage can be reduced in the future with the gradual adoption of irrigation management tools and water conservation practices by area vineyards.

One of the most successful outcomes of this project was the creation of the baseline vineyard water usage data set, which showed clearly what the average annual water usage is in area vineyards, and how this usage varies from year to year depending upon winter rainfall amounts. This data has been used extensively in the ongoing Groundwater Basin modeling work. It was used to inform all parties involved in the discussion of addressing the water supply problems of the Basin about what the actual water usage of local vineyards is, and identified areas where savings can be achieved (e.g. the few excessive water users).

Many areas of California are now grappling with having to create groundwater management agencies to manage high- and medium-priority groundwater basins in the near future. None of these other areas will be able to create an agency that will have available to it from its very first day of operation the type of detailed water consumption data such as will be available to the future district managing the Paso Robles Groundwater Basin, due to the efforts of this project. Having this baseline data available from day one will allow the future district to quickly develop meaningful management programs based on accurate data; this avoids costly and potentially damaging delays that could exacerbate water supply problems within the Basin. Additionally, the irrigation management and water conservation tools also developed in this project will be available to be used by the future district to help growers attain the highest possible water use efficiency. If having better water use data, as developed in this project, can for example help stave off an adjudication of the groundwater basin and instead facilitate community support for the prompt creation a local groundwater sustainability agency (district), this will save the very large amount of legal fees (many millions of dollars) and long court time (a decade is not unusual) that an adjudication of the groundwater basin would entail. The important developments that occurred during the period of this project make it clear that in the near future the basin will be managed by an entity (court or state), and as part of the management task the entity will aim to bring long-term pumping rates in line with the sustainable yield of the basin. Thus pumping reductions or limitations may be an inevitable consequence of this management, however strategies that improve water use efficiency in vineyards can help maintain economically viable crop production levels while using less groundwater to achieve that production. An example of this can be alternative management of cover crops with the goal of maximizing stored soil moisture (from rainfall) for later use by the vines; in some cases this could reduce later irrigation requirements by 10% or more, depending upon the site condition.

Beneficiaries

The primary beneficiary of this project is the commercial wine grape industry that utilizes the Paso Robles Groundwater Basin for irrigation. This includes the direct production of wine grapes in the region, and the associated winery and tourism industries that depend upon the wine grape production for their livelihoods as well (the economic multiplier is several times that of the raw crop value). Currently San Luis Obispo County has nearly 30,000 acres of wine grapes; the majority of this acreage depends upon the Paso Robles Groundwater Basin for irrigation. The main beneficiaries relying upon the data generated in this project are the San Luis Obispo County wine grape industry, of which over 2/3 overlies the Paso Robles Groundwater Basin. Wine, vineyards, related industries, products and services generate $1.8 billion in economic value in San Luis Obispo County (2007, MKF Research LLC). San Luis Obispo County's wine industry is largely concentrated in North County, which is primarily the Paso Robles American Viticulture Area (AVA) and accounts for more than 90 percent of the acreage and 90 percent of the number of wineries in the county, about 82.4 percent of the county's winery revenue and 82.5 percent of county wine production. Fifty-eight percent of Paso Robles grapes are sold out of the county, with more than two thirds of them going into value wines designated for California and Central Coast AVA. The production of wine grapes is the dominant high-value crop over the past decade in the county, and the almost exclusive high-value crop for the Paso Robles area. The economic impact of wine and wine grapes in the Paso Robles AVA includes employing 7,000 persons with a total payroll of $182 million. Wine grapes, now San Luis Obispo County's highest value crop, represents one third of the county's total agricultural production value. With nearly 30,000 acres planted into wine grapes, San Luis Obispo County produced an estimated 148,000 tons of wine grapes The driver of this wine grape economy is the availability of groundwater to support the continued production of high-value crops.

Specialty crop growers benefit from this project because collecting very timely data related to vineyard water use has been critical for the ongoing efforts to model the Paso Robles Groundwater Basin; this work has been conducted by various consulting firms at significant cost to the local government. These increasingly sophisticated models rely upon having high-quality, accurate data to produce meaningful and accurate results. This modeling work over the past decade and a half has been a key tool to specialty crop growers utilizing the Basin for water. A recognized shortcoming has been the availability of accurate vineyard irrigation data. This project provided an extremely robust and comprehensive set of irrigation data for the most recent model update in 2014; having this data greatly increased the confidence in the model output.

The data collected in this project has enabled all persons involved in the complicated and contentious process of determining how and when steps need to be taken to safeguard the Paso Robles Groundwater Basin, to have the most accurate information possible to make the most informed decisions possible. The information developed in this project, and the continued information being provided by the weather station systems established under the project, will impact every single user of water from the basin because this information will be a fundamental component of the future water management decisions made for the basin.

Lessons Learned

The detailed monitoring project at 84 sites to produce accurate vineyard water usage data offers an excellent example of what worked very well in this project. This effort produced a very timely and highly valuable data set that has been utilized by a wide variety of parties from day one, all at relatively low cost. The availability of these results have undoubtedly made a significant impact on many levels in the ongoing efforts to understand the basin and inform the members of in the decision-making process.

The same data though provides a somewhat negative conclusion, in that the measured water applications were on average less than previously estimated; this may limit the potential future savings. There are lower limits of how much water can be applied to a vineyard (with current technology) and to still attain economically viable yields in a given area. If further reductions of water applications lead to lower total crop values, this will not be economically sustainable without increases in crop value. This issue will be a very important one for the area to deal with going forward.

The historic drought in the region greatly accelerated the timeframe for which the type of information developed in this project was needed by industry and all parties involved with the Paso Robles Groundwater Basin. This accelerated need for this information was not at all anticipated when the project was first proposed; rather the information available at that time suggested that a broader water supply problem was more likely to occur farther into the future. The drought moved this need forward rapidly, and in the process the data developed in this project had a much more important and pivotal role in informing the process about how to proceed forward in addressing the Groundwater Basin management challenge.

An entirely unexpected outcome related to this project was the involvement with how irrigated land was developed during the two-year development moratorium that began in August 2013. This moratorium disallowed new development of irrigated land over the Paso Robles Groundwater Basin, but did allow for conversion of different types of irrigated crops on a 1:1 water usage basis (e.g. replacing alfalfa with vineyards). The challenge was then to determine what level of water usage to assign to each crop, such that no net increase in water use would be created if such crop conversion took place. The data from this study provided a very useful guideline to estimate vineyard irrigation usage in this process; it was utilized by County Staff and the local Resource Conservation District in this manner. These crop conversions will continue into the future as remaining low-value, water intensive crops are converted to wine grapes over time.

The primary challenge in conducting this project was the lack of staff to process and analyze data after the staff research associate left. The increased use of automated measurements (for example conducting the extensive 'Surface Renewal' experiment of 2014-2015, and adding sensors and upgrading simple rain gauge stations to more complex weather stations) was employed to alleviate the impact of staffing. However, there was still delay in the final processing of some data collected in this project, and processing of these data sets will continue after the end of the grant period, perhaps into 2017.

Additional Information

The Western Farm Press wrote an article on this project:
http://westernfarmpress.com/grapes/central-coast-weather-research-targets-water-efficiency-wine-grapes

California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.: 46	**Project Title:** Using Targeted High Frequency Nitrogen (N) Applications to Diminish Reactive N Mobilization in Micro-irrigated Perennial Crops and Modeling Applications.	
Grant Recipient: Regents of University of California, Davis	**Grant Agreement No.:** SCB12046	**Date Submitted:** December 2015
Recipient Contact: David R. Smart	**Telephone:** 530-574-3929	**Email:** drsmart@ucdavis.edu

Project Summary

The need for better environmental stewardship by specialty crop growers has become a critical issue particularly with respect to mobilization of reactive forms of nitrogen like nitrous oxide (N_2O) and nitrate (NO_3^-) and. Nitrate contaminates potable water wells and N_2O is a greenhouse gas (GHG) with 300 times the radiative forcing potential of CO_2. Both are generated by application of synthetic fertilizers to agricultural soils. The purpose of this project was to examine an easily adaptable means of fertigation micro-irrigated perennial crops with nitrogen (N) and to examine whether the method diminishes mobilization of N_2O but also other reactive N contaminants like NO_3^-. The problem is that few methods for growers to adapt are currently available and both research findings and educational materials are lacking. The adoption of management practices that reduce reactive N mobilization aids growers in qualifying for 'green' marketing opportunities in addition to addressing regulatory mandates of State and Federal agencies. The objective of the project was to test the management practice of frequent low N applications targeted to tree and vine N demand (root growth, shoot growth and fruit and nut development) as a means of diminishing N_2O emissions and NO_3^- movement below the root zone.

The subject of mitigation of greenhouse gas (GHG) emissions in agriculture (here defined as adopting practices for lessening net GHG production) is one of the most urgent research subjects in the framework of enhancing environmental stewardship. Improving such stewardship is rapidly becoming a key marketing issue in addition to subjecting growers to increasing scrutiny from regulatory agencies. The State of California, for example, is committed to reduce its GHG emissions to the 1990 level by 2020 as called for in approval of the Global Warming Solutions Act of 2006 (AB32), and to an 80% reduction of the 1990 GHG emission levels by 2050, as mandated by Executive Order S-3-05 signed by the Governor on June 1, 2005. No fewer than 18 States have now followed suit. In addition to these actions by State governments, the United States Environmental Protection Agency's recent endangerment finding for GHGs (http://www.epa.gov/climatechange/ghgemissions/) such as CO_2 subjects these gases to scrutiny under the Clean Air Act. The current scoping plan released by the California Air Resources Board (CARB) (http://climatechange.ca.gov/climate_action_team/reports), the State of California regulatory organization charged with implementation of the regulatory process mandated by passage of AB32, calls for "research to address large uncertainties regarding the amount of carbon (C) being sequestered by cropping system management practices, the increased nitrous oxide (N_2O) emissions that results from increasing C in soils…". These are substantial commitments with national and international implications, and the tract California has adopted with respect to GHG mitigation has unavoidable repercussions for future production and marketing.

Further, the UC Davis report undertaken by the California State Water Resources Control Board in response to the SB X2 1 (http://groundwaternitrate.ucdavis.edu/) strongly implicates agriculture in NO_3^- contamination of groundwater wells, rendering numerous wells unsuitable for potable water provision. The Irrigated Lands

Regulatory Program (ILRP, http://www.swrcb.ca.gov/water_issues/programs/agriculture/) regulates water discharges from irrigated agriculture lands and requires corrective actions when impairments are encountered. Thus, the timeliness and importance of this project is unparalleled.

This project is not built upon a previously funded Specialty Crop Block Grant Program.

Project Approach

- Four sites were tested for the proposed high frequency, low nitrogen concentration (HFLN) approach. A principal experiment site was established in an almond orchard owned by Paramount Farming Co. and used for monitoring soil N_2O concentration ([N_2O]), soil [NO_3^-], soil surface N_2O emissions, soil moisture (θv) and soil water filled pore space (WFPS), as well as NO_3^- leaching using suction lysimeters. Monitoring this intensive site was undertaken periodically over a two year period (2013-2014). Over 2,000 samples and observations were taken and successfully used to make an initial sensitivity analysis of the HYDRUS model (Wolff, Ph.D. thesis, University of California, Davis).
- Three satellite sites were established consisting of an almond and a pistachio orchard in Madera Co. and an almond orchard in Stanislaus Co. thus providing parallel information for three other soil types.
- Soil surveys consisting of characterization of chemical and physical properties, and effective rooting zone were undertaken at the Belridge and Madera orchards.
- Almond and pistachio yields for the proposed high frequency low N (HFLN) treatment were gathered and compared with yields achieved using conventional grower practices. The yields for the HFLN method did not statistically significantly differ from those of the conventional practice at all sites. Thus important grower information was gathered for demonstrating to practitioners the absence of any economic consequence of adapting the HFLN method of fertigation.
- An unusual development the project team encountered was that the HFLN treatment realized a slightly greater percentage of N fertilizer was lost to N2O emissions.
- A favorable development was that we encountered less potential leachable NO_3^- at the lower depths in 1 of 3 monitored trees in the almond orchard at the satellite sites and this has provided information on how within orchard heterogeneity in soil horizonation, specifically water impeding layers, will make modeling efforts challenging to undertake.
- Another favorable accomplishment was the suitability of the gathered soils and N_2O emissions data for calibration of the Denitrification Decomposition model (DNDC) which will ultimately be embedded in decision support systems for N management of woody perennial specialty crops.

The overall scope of the project did not enhance the competitiveness of any crops other than micro-irrigated N-intensive woody perennial specialty crops.

The Almond Board of California (ABC) strongly contributed to the project by providing grower meetings and other outreach venues. The ABC and the California Pistachio Research Board played a critical role in helping to identify and enroll grower/cooperators into the program.

Goals and Outcomes Achieved

The performance goals and measurable outcomes were achieved by attending grower meetings and publishing grower proceedings advisories in conjunction with the meetings. The completed activities include the following:

Schellenberg, DL, MW Wolff, MM Alsina, CM Stockert and DR Smart (2013) Net Primary Productivity and Greenhouse Gas Exchanges for Major California Perennial Crops. Farming for the Future: California Climate and Agriculture Summit, February 21st, California Climate Action Network (Cal-CAN), Davis, CA, >200 attendees.

Smart, DR, PH Brown, G Ludwig (2013) Nitrogen Use Efficiency of California Almond Orchards, USDA Central Valley Nitrogen Efficiency Conference, June 6th, Modesto CA, 40+ attendees

Wolff, MW, DL Schellenberg, A Olivos, BL Sanden, PH Brown and DR Smart (2013) Reducing Mobile-N Loss from Fertigation: Field and Modeling Approaches. Improving Nitrogen Use Efficiency in Crop and Livestock Production Systems, Soil Science Society of America, August 13-15, Kansas City MO, >200 attendees.

Salas, W, DR Smart, J Kimmelshue (2013) DNDC Modeling Update, Sustainability Strategic Meeting, Oct 31st, 12 attendees.

Smart, DR (2013) Mitigation of Reactive N Mobilization (N_2O and NO_3^-) Using Injected, High Frequency Low Nitrogen Fertigation (HFLN). Almond Board of California Annual Meeting, Dec 3rd-5th, Sacramento CA, 2,555 attendees.

Smart DR (2013) Optimizing the Use of Ground Water Nitrogen in Nut Crops. Almond Board of California Annual Meeting, Dec 3rd-5th, Sacramento CA, 2,500+ attendees.

Smart, DR (2013) Mitigation of Reactive N Mobilization (N_2O and NO_3^-) Using Injected, High Frequency Low Nitrogen Fertigation (HFLN). Almond Board of California Annual Meeting Proceedings/Research Updates.

Smart DR (2014) Sustainable Management of the Root Zone, Sustainable Agriculture Expo, San Luis Obispo CA November 17-18th, >400 attendees.

Baram S, M Read, CM Stockert, T Harter, P Brown, JW Hopmans DR Smart (2014) Optimizing the Use of Groundwater Nitrogen (NO_3^-): Efficacy of the Pump and Fertilize Approach for Almond. Almond Board of California Annual Meeting, Dec 9th-11th, Sacramento CA, 2,925 attendees.

Smart, DR, S Baram, M Read, CM Stockert, T Harter, P Brown, JW Hopmans, (2014) Optimizing the Use of Groundwater Nitrogen (NO_3^-): Efficacy of the Pump and Fertilize Approach for Almond. Conference Proceedings/Research Updates.

Dabach, S, DR Smart, M Read, C Stockert (2014) Evaluating Nitrogen Management Strategies to Minimize Greenhouse Gas Emissions from California Almond Orchards. Almond Board of California Annual Meeting, Dec 8-10th, 2,925 attendees.

Smart, DR, S Dabach, M Read, C Stockert (2014) Evaluating Nitrogen Management Strategies to Minimize Greenhouse Gas Emissions from California Almond Orchards. Almond Board of California Annual Conference Proceedings/Research Updates.

The outcome measures are long-term. It was only during the 2015 growing season (September 2015 harvest) that sufficient data (two full seasons) will have been collected in order to have comprehensive results for the satellite sites. Data from these sites will provide sufficient observations for knowing definitively whether or not the HFLN nitrogen management strategy will diminish GHG emissions of N_2O and reduce the rates of mobilization of NO_3^- below the root zone. The project team has been contacted e.g. by International Innovations (with over 120,000 stakeholders) to feature an article. An article is planned for California Agriculture but, once the data have been thoroughly scrutinized.

There were only a few accomplishments the project team did not completely achieve for the goals set out for the 2012-2015 duration of the funding period. But this was mainly accountable to the fact that the team had only recently finished the second season of data gathering from the satellite sites. Thus the final HYDRUS sensitivity analysis and modulating for an N_2O component will need to be carried out in the future. In addition, the project in its initial inception called for at least three satellite sites of which one site was proposed to be a vineyard. It was difficult to have three sites because there was not enough staff to make visits to the proposed vineyard sites (that were more than 240 miles away from UC Davis). Additionally, the distance from UC Davis and the sites created challenges of establishing relationships with grower/cooperators and various management practices. However, the project team did end up having three satellite sites but all three were either almond (2) or pistachio (1) orchards. This did not adversely impact the initial goals of the project.

The major research targets of 1) N fertilizer loss as N_2O-N, 2) quantifying potential leachable NO_3^- 3) HYDRUS model sensitivity analysis, were achieved and the illustrated baseline data include:

1) The current N_2O-N emission factors for 1 season at the principal intensively monitored site (Belridge, 2013) and two of the satellite orchards (Madera Co., 2014) have tentatively indicated that advanced grower practice (AGP) has less N_2O-N emissions than the high frequency low nitrogen concentration approach (Table 1). Nonetheless these results require verification for the 2015 season when side by side measurements were obtained from micro-sprinkler fertigated almonds and pistachios were monitored. The data highlights the complexity of obtaining comparable treatments at grower/cooperator sites.

Table 1: Percentage of fertilizer N lost as N_2O (emission factor).

Location	Irrigation Method	Fertigation Strategy	Fertilizer	Emission Factor
Belridge	Drip	AGP*	UAN$^{\zeta}$	0.23%
Belridge	Drip	HFLN$^{\xi}$	UAN	0.31%
Madera	Micro-sprinkler	AGP	UAN	0.07%
Madera	Micro-sprinkler	HFLN	UAN	1.86%

*AGP = Advanced Grower Practice, ramped up split applications targeted to tree N demand and adjusted according to springtime leaf N concentration.
ξ HFLN = High frequency low nitrogen concentration, 5% of total seasonal fertilizer N anticipated injected during each of 20 irrigation events.
$^{\zeta}$UAN = urea ammonium nitrate, 32% N.

2) The intensively monitored sites (Belridge) provided data regarding governing factors for predicting N_2O emissions (Figures 1A & B). Principal component analysis revealed that soil N_2O concentration in the upper soil air filled pore space (7.5 cm) was the best predictive parameter for N_2O emissions for both drip and microjet sprinkler emitters (Figures 1C & D). Under drip irrigation, soil N_2O concentration was well correlated with NH_4^+ during the first day following N fertilization (DAF1) and with NO_3^- in DAF3 (Figure 1C). These results indicated nitrification was the transformation producing N_2O early. As the substrate concentration for nitrification, $[NH_4^+]$ decreased and CO_2 levels increased in the soil, the primary transformation producing N2O appeared to shift to denitrification, perhaps in anaerobic microsites, hence the lower correlation with extractable soil NH_4^+ and the positive correlation with extractable soil NO_3^-. There was a statistically significant high positive correlation between soil N_2O and soil extractable NH_4^+ (R^2 = 0.82), WFPS (R^2 = 0.93), and CO_2 (R^2 = 0.81) (Table 2). During the following time periods, correlation coefficients for all parameters decreased until day 3, when they were R^2 = 0.76, 0.45, 0.59, and -0.24 for NH_4^+, WFPS, CO_2 and NO_3^- respectively. It seems that nitrification was the governing process affecting N_2O emissions during the 3 days of measurement, mainly because of the relatively high correlation with NH_4^+.

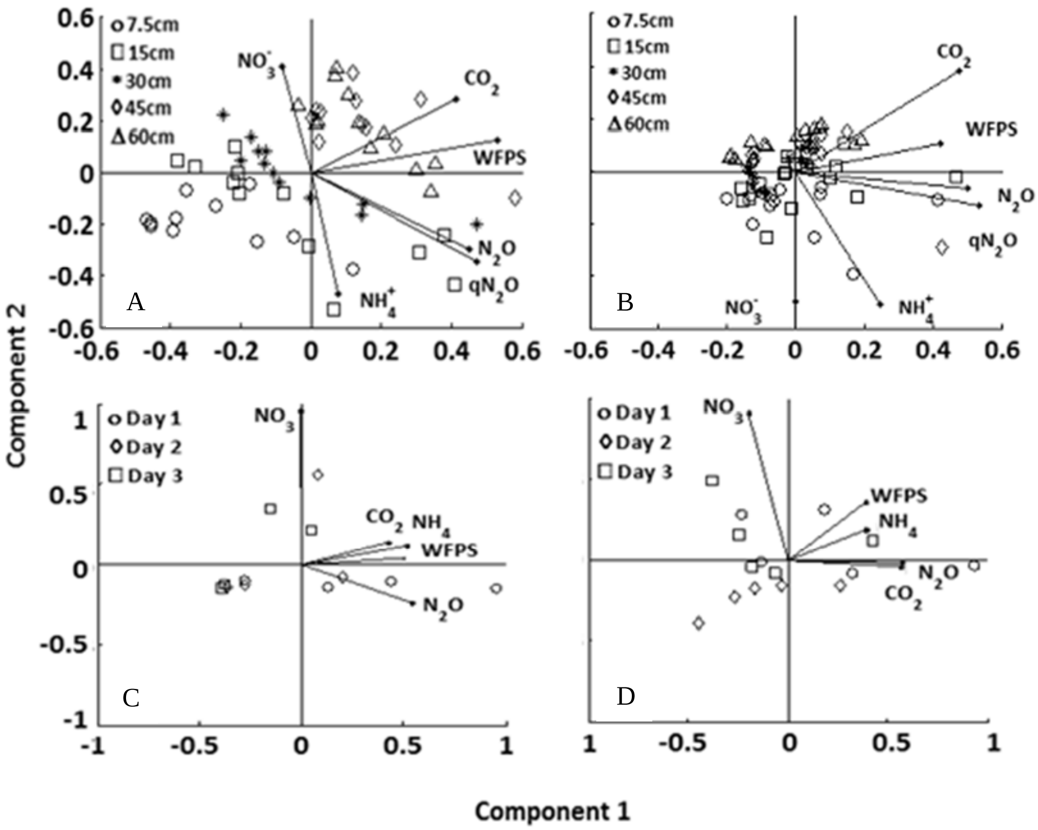


Figure 1: Principle components analysis (PCA) for soil [NO_3^-], soil [NH_4^+], soil pore space CO_2 and N_2O and soil water filled pore space (WFPS) Shown are for drip (A, C) and fanjet (B, D) for all measurements (A, B) and only measurements taken at a depth of 7.5 cm (C, D).

Table 2: Correlations of N_2O-N emissions with other critical soil factors.

	NH_4^+	*NO_3^-*	*WFPS*	*N_2O-N emissions*
NH_4^+	1.00			
NO_3^-	0.713	1.00		
WFPS	0.665	0.398	1.00	
N_2O-N emissions	0.514	0.625	0.691	1.00

3) Sensitivity analysis of the HYDRUS 2D model for inclusion of a N_2O subroutine is depicted in Figure 1. Moreover, this baseline data indicated that lateral movement (likely bulk flow) soil NO_3^- concentration ([NO_3^-]) was the major indicator of why surface N_2O emissions have a dual peak pattern (Figure 1, left panel). This is an important factor in developing a model subroutine because growers generally 'chase' injected fertilizer with irrigation water. In other words, during a 20 h irrigation event all the injected fertilizer can be depleted within the first 4-6 hours while the irrigation portion of the application continues a further 16 to 18 hours.

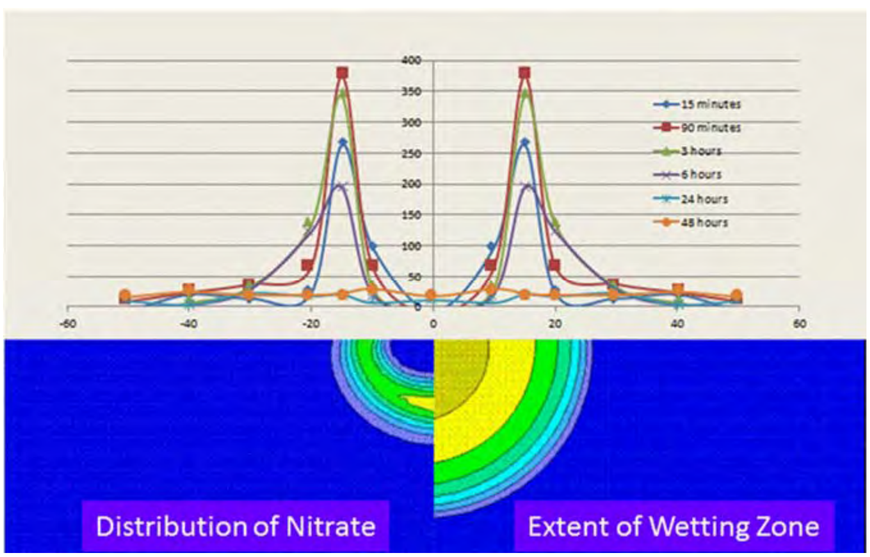


Figure 2: Two dimensional (2-D) spatial distribution of instantaneous N_2O emissions around the drip emitter (space x time) measured for 48 hour time interval, as per the depth x distance from drip emitter impact zone (0, 0) of nitrate (left lower panel) and water (right lower panel) as modeled by the HYDRUS 2-D model.

The major successful outcomes include gathered databases with over approximately 1,000 observations that can be used for calibration and development of the HYDRUS 2D/3D model and calibration of the DeNitrification DeComposition (DNDC) model for California conditions and practices. A major successful outcome of the project was the communication of results to greater than 4,000 stakeholders, some of which attended multiple meetings, over a two and one half year period.

Beneficiaries

The industries that most directly benefited from the completion of this project included California almond and pistachio growers. In addition, many of California's woody perennial specialty crops growers, including grape, benefited from direct measures concerning proposed Best Management Practices (BMPs). The California Air Resources Board, the Almond Board of California, the California Pistachio Research Board, the California Department of Water Resources, the Irrigated Lands Regulatory Program and many other commodity boards and regulatory agencies benefited from the completion of this project because it demonstrated direct data for proposed grower BMPs.

The direct beneficiaries include the nearly 6,800 almond growers in California (USDA NASS) and the estimated 1,100 pistachio and walnut growers statewide. The potential numerical economic impact is difficult to directly measure because the cost of N fertilizers varies depending on the form used, region and time. In addition it is nearly impossible to put an economic impact on the ecosystem service of diminishing reactive nitrogen such as leaching of NO3.

Lessons Learned

A strongly positive result and lesson learned was strong cooperation with California Commodity Boards, mainly almond and pistachio, and with California State regulatory organizations. This allowed for the project team to foster communications with growers and other stakeholders in a manner that otherwise would have cost staff researchers tremendous time and effort. A negative lesson learned was in attempting to broaden the effort to a number of woody perennial specialty crops that would have required research staff time spent on understanding multiple N management scenarios, individual grower practices and would have increased travel time and expenses to levels beyond the actual scope of the project. Focusing on two commodities (almond and pistachio) with similar N demands and water management scenarios was a fundamentally coherent decision.

An unexpected outcome of the project was the finding that management of N fertilizer injection rather than changing frequency or quantity of N injected was more important to minimizing N mobilization than fertigation strategy per se. For example injecting N towards the end of a fertigation/irrigation event rather than at the beginning seemed to lessen reactive N mobilization. These data highlight that it may be water management rather than any single proposed best management practice that is of utmost importance.

The reason outcomes with respect to modeling applications were not achieved according to original goals was the funding period of 2.5 years was insufficient to accomplish more than field experimentation and data gathering. Therefore, the lesson learned is to focus on two commodities at a time to achieve the most efficient results.

Additional Information

Wolff, Michael W. (2015) Effects of drip fertigation frequency and N-source on soil N_2O production in almonds. Ph.D. Thesis, University of California, Davis.
An early website news bulletin, Fertilization Methods Reduce Greenhouse Gas Emissions https://gradstudies.ucdavis.edu/news/fertilization-methods-reduce-greenhouse-gas-emissions.

Dabach, S, D Jerszurki, CM Stockert, DR Smart (2015) Discerning mechanisms controlling N_2O emissions by drip and micro sprinkler irrigation systems in an almond orchard. *Soil Biology and Biochemistry* (in review).

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 47	**Project Title:** Establishing Cost Efficient Methods to Measure Nitrate Movement Beyond the Root Zone When Using Nutrient BMPs in California Specialty Crops	
Grant Recipient: Coalition for Urban/Rural Environmental Stewardship	**Grant Agreement No.:** SCB12047	**Date Submitted:** December 2015
Recipient Contact: Parry Klassen	**Telephone:** 530-756-5200	**Email:** pklassen@unwiredbb.com

Project Summary

Nitrate is the most common contaminant in Central Valley and Central Coast groundwater and elevated levels are attributed primarily to leaching of nitrogen fertilizers past the root zone into aquifers. This project will identify and pilot test scientific methods capable of measuring the movement of nitrates beyond the root zone of an irrigated specialty crop when used in combination with proven nitrogen Best Management Practices (BMPs). Researchers currently use several methods to measure nitrogen movement beyond the root zone (lysimeters, ion exchange cartridges, soil core analysis, nitrate-specific probes). However, it is unclear what method is best for implementation on a large scale as numerous future studies are performed. A literature search and interviews with current researchers and private entities that use these methods identified a scientifically acceptable and cost effective method to measure leaching of nitrate past the root zone. The field studies evaluated these methods under natural conditions.

Regional Water Boards are implementing new groundwater quality regulations that require growers to complete Nitrogen Management Plans (NMPs) with nitrogen budgets and implement nitrogen BMPs to reduce leaching. As part of numerous regulations in different regions, growers are being required to demonstrate that the management practices implemented are protective of groundwater quality. In the Central Valley, this demonstration involves field studies performed as part of the Management Practices Evaluation Program. However, almost no data are available (benchmark) to answer the question of nitrate leaching for the 200-plus specialty crops grown in California and there is immediate regulatory pressure to understand the impact of nitrogen fertilizers on groundwater resources in the Central Valley and Central Coast. To perform the required field studies in a cost effective manner, and to provide growers of specialty crops in California with accurate information on the effectiveness of management practices, there is a critical need to identify methods capable of measuring the amount of nitrogen leaching below the root zone. This study provides that critical information for entities performing studies for growers of specialty crops. Growers of specialty crops can now confidently use information generated by these studies to guide implementation of management practices in a cost effective manner.

This project did not build upon a previous Specialty Crop Block Grant Program project.

Project Approach

Phase I – Compare performance of two lysimeters under field conditions

Task 1. Search available literature for methods for measuring nitrate leaching below the root zone – A literature survey was conducted and 13 methods for tracking/measuring nitrate in soils were identified. All 13 methods were evaluated for possible use in this project. Evaluation included describing the purpose, commodities on which the method has been used, measurement depth/soil type restrictions, sample period, drawbacks, benefits, results, and the reference(s) from which the information was obtained. A Technical Memo discussing the literature review and expert opinion is included as Attachment 1.

Task 2. Interview experts on evaluating nitrate leaching in soils – Six experts from various agencies including USDA Agricultural Research Services (ARS), CDFA Fertilizer Research and Education Program, California Department of Pesticide Regulation, and UC Davis, and an independent consultant were willing to be interviewed and provide an opinion about methods. See Attachment 1.

Task 3. Use literature and expert input to identify effective and cost efficient nitrate leaching measurement method to pilot test – Based on the literature review and expert opinion, a suction lysimeter was identified as the best method of obtaining pore water samples for a reasonable cost. Two different lysimeter configurations were selected for testing; a standard suction lysimeters (Irrometer), and sampling system involving a tensiometer, vacuum unit, and sample bottles (Underground Monitoring System - UMS).

Task 4. Identify growers with walnuts and broccoli and execute agreements with cooperators for pilot studies – Three growers were identified as cooperators: a walnut grower near Stockton, CA, and three broccoli/leafy green growers in the Salinas and Santa Maria Valleys. Because of the crop rotations, the experiments were performed on lettuce. An ingress-egress agreement was developed and executed with all cooperators.

Task 5. Develop study plans (stratified random design with randomly selected fields, random locations of sample devices in each field) – Walnuts: The UMS and Irrometer systems were installed near the northwest corner of the orchard, about 50 meters into the orchard from the eastern boundary. A short trench was dug between two trees, and the UMS control box, field box, and pore water samplers were all installed in close proximity to each other. The ceramic pore water samplers were installed again at two depths; one at 4 feet and the other at 7 feet due to an impermeable clay layer. The three sets of Irrometers were installed approximately 5 meters away from the UMS system; one in the same row of trees and one in each of the rows adjacent to the UMS system. The two Irrometers were installed at a depth of 4 feet and 5 feet. Lettuce: Each of the three lettuce fields chosen were between 15 and 20 acres and both sets (Irrometers and the UMS system) of samplers were installed in a similar manner. The UMS system control box was placed at the edge of each of the fields and a trench was dug between about 10 and 13 meters into the field. At the end of the trench, one ceramic pore water sampler was placed at a depth of 8 feet and the other at a depth of 4 feet. The field box with the sampling bottles placed 3 meters back from the end of the trench and buried to just above ground surface.

Collection of the pore water was timed to occur immediately following irrigation at each field. Just prior to irrigation, any residual pore water was cleared from the Irrometers and the UMS sample collection bottles. A vacuum of approximately 75 psi and 50 psi was put on the deep and shallow Irrometers respectively. The UMS vacuum controller was set between 450 hPa and 600 hPa for the deep sampler and 150 hPa to 500 hPa for the shallow sampler, depending on the soil conditions of the respective field.

The collection of the pore water from the samplers generally occurred at least 16 hours after the vacuum was pulled. Samples were collected from the Irrometers by loosening the rubber stopper, opening the finger clamp, using a disposable syringe to pull the water out of the tube, and squirting the water into a sample container. The syringe is rinsed with deionized water between each collection. Samples from the UMS system are collected by opening the field box, unscrewing the sampling bottle cap, and pouring the sample from the bottle into a sample container.

Task 6. Obtain equipment needed for pilot studies – Two sets of equipment were obtained, suction lysimeters (Irrometers) and UMS systems. The Irrometer is a lysimeter that consists of a clear plastic body, a porous ceramic tip, a neoprene stopper, a vinyl suction line and plastic suction line clamp. Pore water is pulled through the porous ceramic cup by applying a vacuum to the suction line and clamping the line closed. Installation requires inserting the Irrometer into a hole that has been augered slightly smaller than the diameter of the Irrometer which ensures a good connection with the surrounding soil. The UMS system is a tensiometer controlled vacuum system that applies a specified vacuum when a user-set soil moisture is reached. The UMS system consists of 4 main components; the VS-pro vacuum system, a tensiometer, ceramic pore water samplers, and a set of sampling bottles housed in a field box. The VS-pro vacuum system is capable of operating two independent pore water samplers. Installation requires mounting the control box in or near the field, running vacuum lines to the sampling bottles in the field box and then down to each of the ceramic pore water samplers. This requires a linear trench of various lengths dependent on the crop and location in the field.

Task 7. Test the efficacy of the nitrate leaching measurement method in pilot studies – The Irrometers were successful at collecting pore water samples in a majority of the fields. In the three lettuce fields, the Irrometers were able to consistently collect samples when a vacuum was applied. However, in really well drained soils such as the field in Gonzalez, the water moves through the root zone quickly and it is important to time the sampling very closely with irrigation. A low tension ceramic tip is available for the Irrometers that may aid in collecting pore water samples in coarser soils. In the walnut orchard, which contains less permeable soils than the lettuce fields, the Irrometers were not effective at recovering pore water samples. This could be a result of the suction lysimeters running out of vacuum before irrigation water was able to percolate through the soil and reach the ceramic cup or due to preferential flow paths within the clay layers that never allowed water to reach the depths of the suction lysimeter. The suction lysimeters are inexpensive, simple, quick to deploy, and can reliably collect pore water samples if sample collection is properly timed with irrigation or storm events.

The UMS system was also able to consistently collect pore water from the 3 lettuce fields with a manual suction (not using the tensiometer feature) but not in the walnut orchard. The key feature of the UMS is the ability for the vacuum system to be controlled by the tensiometer and collect samples automatically when moisture is present. The tensiometer control works by measuring the difference between the soil moisture and a user defined value and activating the vacuum pumps when the difference in tension is reached. This feature only worked properly on the UMS system installed in the walnut orchard. It did not work at all in any of the three systems installed in the lettuce fields. It is believed that this failed to work in the lettuce fields because they were irrigated such that there was no break in the water moving through the root zone and thus the soil stayed too moist for the tensiometer control to work properly. This resulted in a constant vacuum being required to collect any water moving through the root zone which reduced the temporal reliability of the data. Vacuum leaks were also an issue with the UMS system. The setup outlined in the user manual required multiple connections and fittings which increased the likelihood of a leak. Vacuum leaks kept the UMS system from reliably applying the user define vacuum to the pore water samplers and drained the battery quickly.

Task 8. Analyze data – Data were analyzed and a short summary of results is included at the end of this report. The nitrate results from Phase I are reproduced below (blank cells indicate that a sample could not be collected during that event):

Site	Date	Nitrate as N (mg/L)							
		UMS		*Lysimeter Set 1*		*Lysimeter Set 2*		*Lysimeter Set 3*	
		Shallow	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**
Gonzales	8/30/2013	13	170		100		72		130
	9/12/2013	267.9	170		35		4.2	1.8	130
	10/1/2013	230	160						
	10/2/2013	300	180						
	2/13/2014	260							150
	2/26/2014		150		120		170		
	2/27/2014		150		100		170		
	4/2/2014		190						
	4/28/2014		190						
	5/16/2014	260			98				150
	6/1/2014		170		110		210		130
	6/12/2014	330	170		95				120
	6/13/2014		150	59	77		170	95	100
	6/22/2014		140	56	90		160		92
	6/24/2014		130	57	78		160	90	110
	7/10/2014		190	53	94			110	110
	7/16/2014		150	63	81			72	99
	7/31/2014	240	190	84	28		190	68	79
Salinas	7/18/2013		56						
	7/31/2013		76						
	8/30/2013			6.8		6.9	20	29	50
	9/12/2013	56	121			0.21	0.66		39
	10/1/2013	72	140	5.7		5.6	3.5		0.87
	10/2/2013			95		27	100	16	94
	10/10/2013	71		27	13	9.2	47		70
	10/16/2013	42	150	28	5.9	3.3	58	35	110
	11/26/2013		150						
	2/12/2014		140						
	2/13/2014		140						
	2/26/2014		150	0.21	63	59	110		56
	2/27/2014		120	3.5	93	72	120		69
	4/2/2014	98	160		11	13	20		25
	4/28/2014		170						
	5/7/2014		150						
	5/16/2014		170						
	6/1/2014	110	160						
	6/12/2014		250					5.3	
	6/13/2014		230	110				13	
	6/22/2014	150	250	19				0.42	36
	6/24/2014			51	35			23	33
	7/16/2014	100	170					0.088	

Site	Date	Nitrate as N (mg/L)							
		UMS		*Lysimeter Set 1*		*Lysimeter Set 2*		*Lysimeter Set 3*	
		Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
	7/31/2014	110	170					<0.01	
	8/4/2014	110	180						
Santa Maria	9/12/2013	60	75						
	10/30/2013	70	70						
	11/6/2013	62	74		28		87	45	43
	11/21/2013	70	65		29		68	5.7	36
	1/16/2014	27	12	0.13	26	6.7	19	0.97	17
	1/27/2014	2.1	18						11
	6/5/2014	58							
	6/24/2014	43	37		54			<0.01	33
	6/25/2014	32	33	46	51		42	7.8	20
	7/16/2014	25	38	<0.01	26	0.64	18	<0.01	0.99
Stockton	7/31/2013		2.5						
	8/13/2013		1	0.046				90	
	3/4/2014					<0.01			
	4/3/2014	5.7	0.2			<0.01	1		
	5/15/2014	4.8	0.32						
	5/19/2014						<0.05		0.089
	5/20/2014						0.26		0.39
	5/21/2014						<0.05		
	8/6/2014			32		150			
	8/27/2014	7.3	0.2						
	9/2/2014	4.6	0.58	3.5		55			
	10/7/2014	1.1	0.39			<0.01			

Task 9. Report findings; verify effectiveness of nutrient management plan or make recommendations for modification (if deficient) – The Project Director has given several presentations to growers of the results of this study. Findings from this study were reported to various groups involved with agricultural research on nitrogen fertilizer applications to crops and the potential impact of those nitrates to groundwater quality. Results of this study have been summarized as an addendum to this report (Attachment 2).

Task 10. Distribute project findings – A powerpoint presentation was developed and used in most presentations (some presentations were verbal only reports) that explained the study design, field locations, crops and results of using the various instruments. Of note is the presentation of the results of Phase II of the study to the Northern Central Valley Management Practices Effectiveness Program Coordinating Committee (Attachment 3). This group will utilize the information gained in this study as the basis for future field studies to be performed in the Central Valley as mandated by the Regional Water Quality Control Board. This project findings will be important in guiding the selection of the type of instruments, their density of locations and collection of water and data from specific fields were best management practices are implemented. The entities and presentation dates include:

- Central Coast Regional Water Quality Control Board/Western Growers Assn/Central Coast Groundwater Coalition, Salinas, CA; October 14, 2014. (18 attendees)

- Joint meeting of the Grower-Shipper Association of Central California, management group and Central Coast Groundwater Coalition, board of directors executive committee, Salinas, January 12, 2015. (32 attendees)
- AgroCulture, Inc., Salinas, February 18, 2015; presentation at nitrogen issues meeting to their company management, CA retail distribution companies and California fruit and vegetable growers. (35 attendees)
- Central Valley Management Practices Effective Program, Coordinating Committee; Modesto, March 24, 2015. (8 attendees)
- Sacramento Valley Water Quality Coalition, Management Advisory Group: Woodland, March 25, 2015. (25 attendees)
- CURES Board of Trustees meeting, Sacramento, May 4, 2015. (10 attendees)
- East San Joaquin Water Quality Coalition, member meetings; Madera (105 attendees), Merced (160 attendees), Modesto (250 attendees); May 14, 19, 20, 2015.
- Grower-Shipper Association of Central California, Water Committee: Salinas, June 16, 2015. (35 attendees)
- Actagro Inc.; Company management and research group. Fresno, CA, August 6, 2015. (15 attendees)

Phase II – Determine if suction lysimeters can detect differences in the amount of water moving past the root zone under two different management scenarios

Task 1. Identify grower with broccoli/lettuce and execute agreements with cooperator for study

Task 2. Develop study plan (stratified random design with randomly selected fields, random locations of irrometers in each field) – A single 16.7 acre field was divided into two blocks. Each block was planted and irrigated identically. The primary difference between the two blocks is one side received approximately twice the amount of nitrate fertilizer through the drip system than the other side of the field. Each block was gridded out into 30 cells. All measurements described below were collected from a random location in each grid cell, or in a subset of randomly selected grid cells. Four types of measurements were collected during the study; soil permeability, nitrogen in soil, nitrate in irrigation water from just below the root zone, and nitrogen in the Romaine at harvest. The Irrometer methodology identified in Phase I was utilized to collect pore water samples for nitrate analysis.
Soil permeability – a permeameter was used to determine permeability of the soil in 15 randomly selected grid cells in each block of the field.
Soil nitrogen – prior to planting, five randomly selected grid cells in each block were identified and soil samples were collected to determine the amount of nitrogen in the field prior to planting.
Irrigation water moving past root zone – a suction lysimeter (Irrometer) was placed into each of the 30 grid cells in both sections (30 lysimeters total in each block). At the beginning of the study and after every irrigation event, water was collected in the lysimeters and analyzed for nitrate.
Nitrogen in Romaine tissue – at harvest, five random heads of Romaine were collected from each block. Each head was trimmed as normal during harvest and both the culled tissue and the Romaine heart were analyzed for moisture content, crude protein, and total N content.

Task 3. Analyze data – Data were analyzed and a summary of results is included at the end of this report. Briefly:

1. The blocks did not differ in the amount of nitrate present in the soil prior to planting. Any differences in nitrate leaching past the root zone were the result of nitrate applied during the crop cycle.
2. The two blocks of the field differed significantly in the permeability with one block of the field being twice as permeable as the other. These differences are not reflected in the NRCS soil classifications for the field. The block that received the least nitrate had the highest permeability with some locations having extremely high permeability.
3. Nitrate leached past the root zone in each block although there was a large amount of variability temporally across the crop cycle, and spatially within and between blocks.
4. The block with the lowest application rate of nitrate and the highest permeability had approximately 50% to 100% more nitrate leaching past the root zone. Although the amount of nitrate leaching past the root zone varied from week to week, there was consistently about twice the nitrate in the lysimeters from the high permeability/low nitrate application block compared to the low permeability/high nitrate application block.
5. There were no differences in the moisture content, crude protein, or total N content of the trimmed tissue or the Romaine head between the two blocks.

Task 4. Report findings; verify effectiveness of nutrient management plan or make recommendations for modification (if deficient) – The Project Director has given several presentations to growers of the results of this study. Findings from this study were reported to various groups involved with agricultural research on nitrogen fertilizer applications to crops and the potential impact of those nitrates to groundwater quality. Results of this study have been summarized as an addendum to this report.

Task 5. Distribute project findings – A PowerPoint presentation was developed and used in most presentations (some presentations were verbal only reports) that explained the study design, field locations, crops and results of using the various instruments. Of note is the presentation of the results of phase 2 of the study to the Northern Central Valley Management Practices Effectiveness Program Coordinating Committee. This group will utilize the information gained in this study as the basis for future field studies to be performed in the Central Valley as mandated by the Regional Water Quality Control Board. Project findings will be important in guiding the selection of the type of instruments, their density of locations and collection of water and data from specific fields were best management practices are implemented. The entities and presentation dates are listed above.

This project solely benefited California specialty crop producers, specifically walnuts and broccoli/lettuce. Project staff performed outreach to specialty crop growers, providing project findings and recommendations. CURES and the Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS) will make the information developed through this study broadly available to other specialty crops, expanding the value and assisting others in BMP efficiency studies and compliance.

Goals and Outcomes Achieved

The project's goal was to establish one or more reliable, repeatable scientific methods to characterize movement of nitrogen fertilizers beyond the plant root zone in walnuts and broccoli, and ultimately, in many of the specialty crops grown in the Central Valley and the Central Cost. Measured outcomes were accomplished during the study although lettuce was used instead of broccoli due to crop rotations; it was concluded that the Irrometer methodology could be used to effectively measure the movement of nitrogen through the root zone.

This project accomplished all of the goals that were established in the proposal. A literature review and interviews with experts in the field led to the testing of two lysimeter systems. One system (simple lysimeters) outperformed the second system (UMS lysimeter) in two different specialty crops. The lysimeters were then used to evaluate a management practice in two blocks of a lettuce field (differences in amount of nitrogen fertilizer applied). The objective was to determine if under field conditions of highly variable permeability of the two blocks, Irrometers could detect differences in the amount of nitrate moving past the root zone. Clear differences were detected indicating that simple suction lysimeters such as the Irrometer can be used by agricultural coalitions and growers to evaluate the efficacy of management practices and determine which practices are protective of groundwater.

Data collected include:

Phase I
1. Concentration of nitrate at different depths in the walnut orchard and broccoli/lettuce fields

Phase II
1. Concentration of nitrate and organic nitrogen (TKN) in soil in each block prior to planting
2. Concentration of nitrate in irrigation water
3. Permeability of soil in each block
4. Concentration of nitrate in lysimeters immediately before and after each irrigation event in both blocks
5. Concentration of nitrate, total N, and percent moisture in lettuce harvested from each block

Numerous methods for measuring the amount of nitrate leaching from the root zone were evaluated and the suction lysimeter was selected for evaluation. Two different types of suction lysimeter systems were evaluated in the field and the simple suction lysimeter was determined to be the best system. Suction lysimeters were used in the field to determine if differences in a management practice could be detected. Differences were observable and were able to be linked to soil permeability. The critical outcomes from this project are:

1. Suction lysimeters, a low cost sampling method, can successfully be employed to determine differences in nitrate leaching under different management practices.
2. The use of suction lysimeters requires active communication between the study team and the grower who is applying nitrate and irrigating the crop.
3. Documentation of the efficacy of suction lysimeters is expected to result in their approval by regulatory agencies as a valid monitoring method for demonstrating that selected management practices are protective of groundwater.

Beneficiaries

In the East San Joaquin Water Quality Coalition (ESJWQC), there are almost 4,000 growers who are members. The immediate beneficiaries are the walnut growers in the ESJWQC region who are required to comply with the Central Valley Water Board groundwater regulations. Additionally, broccoli and lettuce growers in both the Central Valley region (9,800 acres) and Central Coast region (91,000 acres) will benefit immediately from this study. According to the 2012 USDA census, (http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/California/st06_1_038_038.pdf) there are approximately 617 broccoli farms and 1,486 lettuce farms. Similarly, across the Central Valley and Central Coast, there are tens of thousands of growers of specialty crops. All are concerned with nitrate leaching, and all can benefit from the results of these studies. In addition, state governmental entities, such as the Regional Water Quality Control Boards, are tasked with evaluating the data from studies performed by the agricultural community to demonstrate that management practices are protective of groundwater. Information from this study will provide the Regional Water Boards with the tools needed to evaluate proposed studies and effectively protect groundwater resources.

Estimating the number of specialty crop growers in California is difficult. The American Farmland Trust estimated in 2013 that specialty crops were grown by over 50,000 California farmers (https://4aa2dc132bb150caf1aa-7bb737f4349b47aa42dce777a72d5264.ssl.cf5.rackcdn.com/SpecialityCropGrowersBMPs.pdf). A majority of these farmers are in regions where nitrate leaching is a significant concern. As a result, these farmers are, or may be in the near future, required to demonstrate that their management practices are protective of groundwater. Many of these growers are members of agricultural coalitions that are tasked with performing studies that demonstrate the efficacy of management practices. The cost of these studies is borne by the members. Providing the coalitions and the growers with low cost methods and study designs that can be used to demonstrate that their management practices are protective of groundwater could save growers of specialty crops an extremely large amount of time and money.

Lessons Learned

Lessons learned include:
Spending additional funds to obtain reliable equipment (e.g. the permeameters purchased with the matching funds) to provide consistent and reliable results would have made the permeability results much more powerful.

Although capable of producing good data, the UMS required substantially more maintenance than simple suction lysimeters. Combined with the greater initial purchase price, the UMS was not a cost-effective method of obtaining samples. Using the UMS to capture the spatial heterogeneity in the fields would be prohibitively expensive.

Accurate communication with the owners and the field workers is definitely needed with this type of study. To effectively prepare and collect samples, consistent and reliable lines of communication would have made the sampling easier.

Communicating with the farmers to ensure the study design was as solid as possible would also have been beneficial to the study (guarantee the same variety of plant in both blocks; more accurate method of ensuring treatments stay consistent across the entire study).

Additional measures of soil permeability would have provided a better understanding of how permeability affected nitrate leaching. Matching the number of lysimeters to the number and location of permeability measurements is important in interpreting the results.

There are two unexpected outcomes from these studies:

1. The simpler suction lysimeter was more reliable. Systems with more "moving parts" provide more opportunities for system failure and could hinder the ability to obtain the information necessary to measure the concentration of nitrate moving past the root zone and consequently, prevent an evaluation of management practices.
2. The primary determinant of nitrate leaching was soil permeability, not the amount of nitrate applied to the fields. Although the NRCS soil category was the same for both blocks, heterogeneity in permeability within and between blocks was critical in determining the rate at which nitrate moved past the root zone.

With one exception, all outcome measures were achieved in this study. The exception is the development of a peer reviewed publication. Discussions with UC Davis faculty and Cooperative Extension indicate that the results of Phase I would not be sufficiently interesting to warrant publication in a peer reviewed journal. While the results of Phase II might rise to the level of a peer reviewed publication, producing a suitable manuscript requires significant additional analyses that could take several months to complete. A report of the results of both Phases of the study are provided as attachments.

Within the expected measurable outcomes section of the project, there is a description of how this study will affect specialty crop growers within the East San Joaquin Water Quality Coalition. The goal of the study was to validate a method by which BMPs could be evaluated for their effectiveness in reducing the amount of nitrogen moving past the root zone. It was the long term goal of this study to produce a method that could be used by the Central Valley agricultural coalitions to validate BMPs and encourage their adoption by specialty crop growers. The program through which the coalitions will evaluate BMPs is the Management Practice Evaluation Program (MPEP) and the studies are expected to begin in the fall of 2016. Based on the MPEP study results, specialty crop growers will be informed of which practices are more effective at reducing the amount of nitrogen moving past the root zone. This project was not focused on the effectiveness of management practices and therefore the results did not include the validation of BMPs. Because of this, the study was unable to determine that approximately 500 specialty crop growers in the ESJWQC adopted BMPs as a result of this study. It is still expected that the methodologies implemented as well as the lessons learned in this study will be instrumental in future study designs focused on assessing the effectiveness of BMPs. Should these future BMP studies find that growers need to change and improve their nitrogen management practices, it will be likely (and a regulatory requirement) that far more than 500 growers will need to change or improve practices. However at this time, it is premature to determine that number.

Additional Information

Attached to this report are the following:

1. Literature Review
2. CDFA Specialty Crop Grant Final Report Addendum
3. Power Point Presentation

USDA Project No.: 49	Project Title: Building California Bees for California Specialty Crops	
Grant Recipient: Project Apis m.	**Grant Agreement No.:** SCB12049	**Date Submitted:** December 2015
Recipient Contact: Christi Heintz	**Telephone:** 520-834-2832	**Email:** christi@cox.net

Project Summary

California lacks sustainable food resources to build and maintain adequate honey bee populations within the state. There is a need to identify and promote suitable nectar and pollen plants for honey bees that require little water for cultivation. These forage resources should also be nutritionally complete, containing complementary essential amino acids. Most managed honey bees in the United States are required to pollinate California's specialty crops. Almonds alone require 1.8 million colonies. With only half a million colonies in California, there is an urgent need to build more California bees. Currently bees travel from as far away as Maine and Florida to pollinate California specialty crops. Given a sustainable food supply for honey bees in California, beekeepers could reduce losses and leave more colonies within the state. Recent data by United States Department of Agriculture (USDA), Agricultural Research Services (ARS) states that starvation plays a major role in bee colony losses. A greater number of available honey bee colonies in California would reduce transportation costs for the beekeeper. A beekeeper incurs considerable costs in labor and transportation to move bees to forage resources outside California's borders. Decreased fuel and transportation costs for the beekeeper translate to savings in pollination rental fees to growers of California's specialty crops. Building bee populations within California will take pressure off the California Border Protection Stations. These stations must annually inspect 2500 truckloads of bees that arrive at the border stations from October through January as beekeepers bring bees into the state to pollinate California specialty crops, beginning with almonds in February. This project identified, developed, and tested specific low-water-use and nutritionally-complete wildflower seed and specialty oilseed mixtures for targeted planting in the Central Valley (CV), Coastal Region (CR) and Sierra Foothills (SF). The project will contribute to sustaining a greater supply of healthy honey bees in California.

This project was timely as the USDA and the Environmental Protection Agency (EPA) in a joint 2013 summary, the White House in a Presidential Memorandum (2014), the National Strategy to Promote the Health of Honey Bees and Other Pollinators (2015), the Honey Bee Health Coalition (2014), the California Department of Food and Agriculture (CDFA) in a Healthy Pollinators Workgroup (2015) and Project Apis m.'s Honey Bee Health Summit at Monsanto (2013) and Project Apis m.'s Honey Bee Research Summit (2012) all identified nutrition and building honey bee habitat as a key priority to improve the health of honey bees.

Honey bee nutrition was an important component of 2009 Specialty Crop Block Grant Program Project 1: *Best Management Practices (BMPs) for Honey Bees Pollinating California's Specialty crops*, and the area of nutrition warranted considerable additional focus; thus 2010 Specialty Crop Block Grant Program Project 19: *Improving Forage Resources for Pollinators of California's Specialty Crops* was developed. The 2010 project was built upon SC107006's objective evaluations of bee health and the 2009 project. This 2012 project particularly complements 2010 project on forage resources, where land managers were enlisted to grow crops timed for fall and spring honey bee forage. The 2010 project's primary measure of success was the number of growers and/or landowners planting bee forage crops and the amount of acreage dedicated to bee forage, with recruitment of twelve to fifteen significant landowners as the target. Whereas the 2010 project identified lands, this grant, fine-tuned flowering species mixes, specifically wildflower mixes and specialty oilseed crops. The interest in specialty oilseed crops has seen considerable growth since the 2010 project was developed and initiated. Specialty oilseed crops for biofuels and the cosmetic industry can include attractive and nutritionally important honey bee opportunities, but few individuals make the connection between plantings of specialty oilseed crops and pollination opportunities. Activities under this grant illuminated the relationship between oilseed crops and honey bee health. The 2010 project evaluated available seed mixtures, whereas this project developed low-water-use wildflower seed mixtures. The 2010 project concentrated on lands near orchards, mainly in California's Central Valley. This 2012 project concentrated on three important areas for honey bee forage plantings; California's Central Valley, the Coastal Regions and Sierra Foothill regions. The foothill regions are included as important areas for honey bees to "rest and recuperate" away from intensive agricultural areas.

Project Approach

Project goals included: Establishing baseline data and tracking progress against these baselines, developing and maintaining the resources to accomplish goals, conducting research on bee-attractive drought-tolerant wildflower and flowering oilseed crops, researching and assessing the nutritional value of diverse flowering species and their nutritional contribution to the honey bee diet, evaluating growth, bloom and timing of fall plantings, developing the horticultural requirements, planting instructions and a resource guide for landowners to use when sowing seeds for honey bee forage, and providing outreach to landowners and land managers on the benefits and suitability of wildflower mixes and flowering oilseed crops for three targeted geographical regions in California – the Coastal Range (CR), the Central Valley (CV), and the Sierra Foothills (SF).

Establish baseline data and track progress against baselines: Benchmarks were established during the initial months of this grant project. Those benchmarks included measures of the current status of bee health, investigating border station bee truckload data as an indicator of the retention of colonies in California, enumerating the number of acres of bee forage planted and the number of honey bee colonies nutritionally supported by this acreage, and quantifying outreach efforts resulting from the Work Plan.

National Agricultural Statistics Service (NASS) and the Bee Informed Partnership (BIP) over-wintering loss data both indicate improved colony health. The number of colonies has increased by about 4% per year, and honey production has also increased. Over-wintering losses are down to about 23% from over 30% two years ago. Of course, efforts from this grant did not directly influence that positive trend; however, the forage project was presented in many different national venues as one of the first dedicated honey bee forage projects, and many more have since been initiated.

Truckloads of bees coming to California for almond pollination declined by over 1,000 trucks or 425,000 colonies from 2012 to 2014. However, that decline probably has more to do with decreased staffing at the border protection stations than an increase in available bee forage in California.

During the grant period, acreage planted to honey bee forage grew from sixty acres to 750 acres. The number of colonies that benefitted for every acre planted would be from two to ten colonies per acre, depending on the density of plantings and the number of colonies in the area. All three regions (CR, SF and CV) contained plantings, with the majority of acres in the CV and in proximity to the greatest bee populations in the state.

Develop and maintain resources to accomplish goals: Collaboration with several cooperators occurred beginning with the initial stages of the project. Over the course of the project, the main collaborators included California State University, Fresno, University of California, Davis, California State Beekeepers Association, and the Almond Board of California. In addition, numerous individual landowners provided land and assistance for trial plots in the CR, SF and CV regions, including Millers Honeybees, Sonoma Wine Company, Paramount Farming, Inc., Placer Land Co., Cummings-Violich, Inc., Favagrossa Farms, B & S Orchards and Bayer Corporation. Several bee brokers were invaluable in their assistance within the interface of bees and almond growers. Adee Honey Farms provided initial and on-going assistance in plant selections attractive to honey bees.

Wildflower seed selection was accomplished with assistance from Xerces Society, Pollinator Partnership, Cornflower Farms, S & S Seeds and Hedgerow Farms. Plants of the Southwest was invaluable for expertise on drought tolerant plant species. Kamprath Seeds, Inc., provided extensive expertise in sourcing seeds and with planting instructions.

Interaction with specialty oilseed crop producers and refiners was made possible in large part due to collaboration with the Agricultural Research Service Soils Lab in Morris, Minnesota. Aveda Corporation, Sustainable Oils, Archer Daniels Midland, Perdue Agribusiness and Technology Crops International were contacts serving to make the connection between honey bee flowering sources and the production of oils.

On-going research on bee-attractive drought tolerant wildflower and flowering oilseed crops: Prior to each of the three fall planting seasons of this project, bee-friendly low-moisture-requiring wildflower and oilseed crops were selected for planting and evaluation. Resources consulted included those named in the seed selection paragraph above. Additionally, recent literature reviews, the USDA plant database as well as the USDA Natural Resource Conservation Service (NRCS) were consulted. The plant species availability and adaptability to the three targeted geographical regions (CR, SF, and CV) was considered. Each year, improvements were made in test planting plots, based upon prior years' experience and recent available information.

Recent literature and presentations on honey bee nutrition have emphasized the important relationship between adequate and diverse forage for honey bees and improved bee health including longevity, colony strength and ability to withstand pests, diseases, pesticides and transportation stressors. The continued drought in California has led to an increase in publications about drought-tolerant, honey bee-friendly plants. Topping the list of drought-tolerant, bee-attractive plants are native plants such as phacelias and California poppy and herbs including rosemary, sage and lavender. Woody perennials require water for establishment, but once established, toyon, coffee berry, buckwheat, bottlebrush and ceonothus provide excellent long-term pollen sources. These perennials are well-adapted to the CV, CR, and SF regions of California. Oilseed crops such as canola, rapeseed, sunflower, calendula, cuphea, echium, and meadowfoam hold promise as dual-use plants that have economical value to the grower while at the same time providing food for bees.

Research and assess the nutritional value of diverse flowering species and their nutritional contribution to the honey bee diet: The following entities were enlisted to assist with understanding the nutritional value of the different plant species: a) Michigan State University, b) Bee Friendly Farming, c) Bee Informed Partnership (BIP), d) University of California, Davis, e) Oregon State University, f) California State University, Fresno, g)

Miller Honey Farms, and h) Midwest Laboratories. Bee Friendly Farming provided a useful guide to amino acid analyses. Collecting enough pollen for analyses, drying the pollen, and conducting the amino acid analyses was an arduous task. The BIP Technology Transfer Teams proved to be the most dedicated and successful individuals. Working with Midwest Laboratories, eventually small 25 gram samples were sufficient for testing. Oregon State University and University of California, Davis, collaborated in pollen collection and identification for the project. As with humans, the highest quality nutritional diet does not come from single protein sources, but from a combination of amino acids from a diversity of flowering sources.

In 2013, the USDA and the Environmental Protection Agency (EPA) named nutritional stress as a top priority for understanding honey bee colonies losses. Recent research by Mattila (PLOS ONE, April 8, 2015) linked inadequate pollen in the early larval stages of honey bees to smaller bees having shorter lifespans and decreased foraging ability. Smart (PhD, Minnesota State University, unpublished thesis) linked nutritional stress to increased pest and disease issues and increased susceptibility to pesticides.

Data on bee health conducted as part of this grant indicated that areas of greater forage diversity had healthier colonies. Brood area, hive weights and weight of pollen intake were measured as indicators of hive health. Pollen intake was measured via pollen traps. Brood measurements ranged from 400 cm^2 to 7300 cm^2, with the greatest brood area associated with the strongest hives and the greatest floral diversity and pollen intake. Hive weights ranged from about 15 to 45 lbs., with the heaviest and most robust colonies being from areas of greatest floral diversity. In the Bakersfield area (southern CV) where precipitation was low and germination was poor, pollen intake was low, brood area was small, hive weights were low and colonies died.

Frame counts were two to three frames greater with forage and brood area usually 30% larger. Mite and viral loads varied more by location than degree of available forage, being highly location- and beekeeper-dependent due to variability in mite management methods and locations visited prior to locating in California. In the southern CV plot, hive weights within rapini sites were heavier, with no difference in the borage sites. In the Waterford location (east side of CV near foothills), there was no difference in frame counts for brood or pollen when comparing colonies near plantings vs. colonies kept distant from plantings; however, the number of frames of honey were higher in colonies near the flower plantings. In a survey of mustard plantings, twenty-four out of twenty-nine respondents said the beekeeper stayed somewhat longer near the forage plantings to take advantage of the forage bloom to build bees after almond bloom. In the Placer (SF) location and in the Waterford (CV) location, beekeepers also recognized the nutrition advantage in building bee health within the forage plantings and stayed longer to build colony strength.

Three borage bloomed from late January through April and meadowfoam bloomed April through June. As was to be expected, frequency of bee visitation closely mirrored bloom timing.

Develop the horticultural requirements, planting instructions and a resource guide for landowners to use when sowing seeds for honey bee forage: Planting guides were developed for Rapini Mustard, Mustard Mix, Capay Clover Mix, Lana Vetch, Hairy Vetch, Purple Vetch, Wildflower Mix, Sainfoin, Borage Oilseed, Camelina sativa, Meadowfoam, and Phacelia ciliata. These guides were accumulated into one document entitled "Forage Resource Guide" that was continually updated and accessible via Project Apis m.'s website. A brochure, "Growers Guide for Planting Honey Bee Forage" was updated to differentiate fall/winter and spring blooming plant species. This brochure contains information on where to plant, how to choose the proper seed, prepare the ground, time planting, control weeds and manage the plantings. A Brassica paper was developed by a collaborating researcher. This paper identifies various members of the Brassica genus of plants that includes canola, rapini and mustard. Benefits to both honey bees and to grower/landowners were outlined.

Provide outreach to landowners and land managers: In April, 2013, a Field Day was held at the Central Valley Cummings plot and approximate forty-five participants were able to view many of the honey bee forage selections planted. The landowner, the agronomy consultant, and the beekeeper all presented on various aspects of the honey bee forage plantings. A video was produced and made available on the Project Apis m. website and on YouTube.

Outreach for 2012-2013 included nine presentations, news articles, video productions and a field day. Articles appeared in "Almond Facts, Barron's, University of California Apiaries News, The Grower, Ag Alert, The Pacific Nut Producer, Western Farm Press, Bee Culture and California Agriculture Today." California Department of Food and Agriculture's "Planting Seeds" highlighted a honey bee forage video. A video on the importance of honey bee forage was produced from the field day held in April, 2013.

For 2013-2014, outreach included presentations at sixteen regional, state and national meetings reaching a total of 1,215 participants. News articles were featured in the Project Apis m. e-newsletter in the months of July, August, and September of 2014; Western Farm Press in July 22, 2014, "Planting Bee Forage Cover Crops in San Joaquin Valley" by USDA)-Natural Resource Conservation Service (NRCS), and an article in the California State Beekeeper's Association e-newsletter the Bee Times published on August 25, 2014. Additionally, there was a photo opportunity of clover mix in the Blue Diamond Growers magazine, "Almond Facts," July-August 2014 issue; and an article in the Almond Board of California newsletter Outlook September 8, 2014, "Fall Is the Time to Plant Bee Forage." A video was edited and scripted, "Why Should Growers Plant a Cover Crop – For the Bees!" narrated by an almond grower participant in Madera County, California.

For 2014-2015, the forage project findings were presented at five state (North Dakota, Montana, California, Wyoming, and Idaho), one regional (Central Valley, California), and two national (American Beekeeping Federation and American Bee Research Conference) meetings to a total combined audience of 1, 140 individuals. Additionally, a presentation was given at CDFA's Healthy Pollinators Workgroup meeting. Sample seed packets were distributed in trade shows during this reporting period where trade show attendees exceeded 3,600 individuals total. Dozens of articles were written about the forage project in agricultural trade magazines such as Almond Outlook, Almond Facts, and Western Farm Press, as well as in local newspapers such as the Modesto Bee. Several radio interviews were conducted, especially for AgNet.West radio. The Modesto Bee posted a video of the forage project. Over the course of the grant, eight new videos on honey bee forage were produced: Bee Forage Field Day, It's All about Forage, AgNet TV Forage Project (168), Seeds for Bees, A Drone's View of Bee Pasture, A Bee's Eye View, Planting a Cover Crop - For the Bees, and Planting a Cover Crop - For the Grower. Total for these eight videos were 4,202 views. The Nutrition Best Management Practices (BMPs) video produced just prior to the start of this grant had 165 views at the onset of the grant. By the conclusion of this grant focusing on building honey bee health and populations via diverse forage, views of the Nutrition BMP video increased to 1,033 views, a gain of over 600%.

Policies and procedures were in place, and were followed, to ensure Specialty Crop Block Grant funds were used to solely enhance the competitiveness of California's specialty crops. Regular communication and/or site visits were conducted with personnel conducting the project activities for this grant. All personnel involved ensured activities were related to the project goals and expenditures of the grant funds were used to solely enhance the competitiveness of California's specialty crops.

Project partners from the University of California Extension and Paramount Farming provided expertise on planting protocols and species. The objectives of the grant were fully discussed with contractors, and seed companies provided assistance in seed availability, compatibility, geographical adaptation and costs. Kamprath Seed, Inc. provided valuable expertise in fine-tuning wildflower mixes. Pollen sampling protocol was established for amino acid analyses, and a cooperative agreement was built with the Bee Informed Partnership (Tech-Transfer) to collect the pollen. Midwest Laboratories was engaged to conduct the analyses.

Specialists from the University of California Extension, California State University and Paramount Farming, Inc., also assisted in identifying cooperator sites in the CV and CR regions. The Bee Biologist for Paramount Farming assisted in interacting with almond growers regarding concerns about competitive bloom between forage plants and the pollinated crop. Adee Honey Farms provided invaluable support on honey bee forage preferences, plant species and bloom timing. The Almond Board of California facilitated contact with almond growers to encourage honey bee forage adoption by growers. The California State Beekeepers Association provided outreach opportunities among beekeepers.

Goals and Outcomes Achieved

Initially, interviews were conducted to learn both about beekeepers current utilization of planted wildflowers to provide diverse nutrition for honey bees as well as beekeeper placement of bees near oilseed crops. Results of those interviews indicated that beekeepers are more likely to move bees out-of-state to better forage resources (many to the Upper Midwest) rather than leave them in California year-round. Of the 1.6 million honey bee colonies required for almond pollination, the largest pollination-requiring crop, less than one-third of those bees are maintained in California year-round. Canola is by far the leading bee-attractive specialty oilseed crop, but California canola acreage is minor compared to the Upper Midwest's acreage. Thus, the significance of specialty oilseed crop locations for honey bees in California is minor. However, specialty oilseed crop acreage is growing. Canola is a fairly drought-tolerant plant. Future opportunities for bee placement near specialty oilseed crop areas will depend on the growth of those crops as well as available water.

Baseline data was established early in the grant period and recorded annually. Extensive literature reviews were conducted and numerous conferences and presentations attended to learn about the latest information available about various wildflower and oilseed crop plant species and their horticultural and geographical requirements. As the grant progressed, the emphasis on drought tolerant species became timely, due to the continued California drought. A baseline of available plant species was established, with improvements in recommended plant species made each year of the grant.

Numerous evaluations were performed throughout the grant period. Data on number of acres planted and types of plant species planted was collected. Timing of bloom emergence, duration of bloom and bee visitation were noted. Planting guides were developed. An assessment of bee health by location occurred, with bee health improved in areas of supplemental bee forage. Bee health indicators included hive weights, frames of bees, frames of brood, mite and viral loads, and pollen collected.

The net outcome of the above activities indicates that the specific measureable outcomes were met; those outcomes were to identify at least three bee-attractive low-water use wildflower mixes, one for each of the three targeted regions (CR, CV and SF) and three specialty oilseed species. For the CR and CV regions, both the mustard mix and clover mix proved to be cost-effective, exhibited a prolonged bloom, and supported honey bee health. For the SF region, the wildflower mix containing Five Spot, Baby Blue Eyes, California Poppy, California Bluebells, Crimson Clover and Persian Clover germinated well, provided good bloom duration and was favored by honey bees. The three top specialty oilseed crops were found to be borage, canola and meadowfoam when evaluating germination and bee activity.

The overall goal for this project was to build a more sustainable food supply for honey bees in California. The specific objectives were to identify, develop and test low-water use wildflower and oilseed mixtures as a means of providing sustainable nutritional resources for the building and retention of honey bees in California. The project far surpassed expectations. The three fall planting periods covered during the course of this grant were maximized for the information they could provide. Landowner-cooperators and test plots were found and developed in all three of the targeted geographical areas, the CR, CV and SF regions. A greater emphasis was placed in the CV region as that is the area where most of the managed honey bee colonies in the United States are placed during the early spring because almond pollination requires a significant portion of all commercial honey bee colonies. Through the fall planting periods, plant species and mixes were continually improved and refined. This project actually yielded three different seed mixes - a mustard mix, a clover mix and a wildflower mix - that were adaptable to all three regions. These mixes were low-water-requiring and exhibited prolonged bloom resulting in extended foraging opportunities for honey bees and contributed to improved colony health. In particular, the mustard mix and clover mix are extremely cost effective and therefore have potential for large scale plantings of hundreds of acres of bee forage supporting thousands of colonies. By design, the mustard mix blooms before the February/March almond bloom and the clover mix blooms after almond bloom. Thus, honey bees could have a continuous and sustainable source of diverse flowering resources from December through April.

The project also evaluated bee visitation and regional performance for a number of individual wildflower species. Far more honey bee-attractive plant species were evaluated than initially planned. Thirty different plant species were tested in different geographical locales. This has resulted in an online guide to plants used by honey bees in California. The Honey Plants of California website is scheduled to go online in early 2016. This project assisted in populating and completing the database for this online guide. Final design and publication costs are being supported by additional external funds. This searchable online database will allow the user to conduct a search for native and horticultural species providing pollen and nectar resources to honey bees. Users will be able to tailor their search by county, elevation, plant life form (herbaceous or woody), drought tolerance and bloom time. Search results will provide general background information about each plant such as life cycle, flower color, height, habitat, and horticultural needs, as well as information critical to beekeepers, such as pollen value, honey value and color of honey produced from its nectar. The website will be found at http://ucanr.edu/sites/hpc/Honey_Plant_Reseach_Database/.

Another goal for the project was to identify three specialty oilseed crops that could be grown both for honey bee forage and as a harvestable crop. Borage, canola, calendula, camelina, cuphea, echium, rapini, and meadowfoam were evaluated. There are four top specialty oilseed crops that have the most potential for both providing a landowner with an economic incentive to plant honey bee forage. Two rapeseeds, canola and rapini, and then borage and meadowfoam could be grown to both provide nutrition for honey bees and a cash crop for landowners. Canola and rapini are early blooming species and thus provide important early nutrition resources for bees, borage provides a long spring blooming season and meadowfoam blooms late spring.

Other accomplishments that served to achieve the broader goals of the project included successfully assessing the interface between bees and plants by evaluating bee health and bee visitation; evaluating plant growth, bloom timing and duration; reviewing the literature for bee-attractive, drought-tolerant wildflower and oilseed crops; developing planting guidelines, a brochure, website resources and videos; and conducting a thorough outreach campaign to demonstrate project results and encourage more landowners and land managers to plant honey bee forage.

Baseline data was established during the initial months of this project. Those benchmarks included a) Measures of the current status of bee health by investigating national bee health statistics including National Agricultural Statistics Service (NASS) data and BIP's over-wintering loss reports, b) Evaluating California Border Protection Station annual bee truckload data as an indicator of the retention of colonies in California, c) Enumerating the number of acres of bee forage planted and the number of honey bee colonies nutritionally supported by this acreage, and d) Quantifying outreach efforts resulting from the Work Plan.

Targeting goals of better bee health have been successful. NASS data indicates improved colony health during the time period of this grant - the number of honey producing colonies in the United States increased by 4% and honey production was up 19% this past year. The previous year (between year one and two of the grant) colonies increased by 4% with honey production up 5% over the previous year. Of course, efforts from this grant did not directly influence that positive trend; however, the forage project was presented in many different national venues as one of the first dedicated honey bee forage projects and many more have since been initiated.

The Bee Informed Partnership over-wintering survey showed over-wintering losses of 31% at the onset of this project. Over one-third of all honey bee colonies died during the winter months. This provides a significant threat to the pollination and crop yields for California's specialty crops and particularly almonds that require the most bees of any crop and require those bees earliest in the spring season. Bee Informed Partnership over-wintering losses at the completion of the project were down significantly to 23%. Beekeepers undoubtedly are recognizing the importance of the role of nutrition in keeping bees healthy and insuring bees are better fed going into winter as well as seeking November, December, and January honey bee forage crops to prevent starvation.

Targeting the retention of bees in California by investigating bee truckloads entering the state, shows an improvement; however, it is probably related more to staffing issues than the fact that more bees stayed in California. Bee trucks entering California for almond pollination declined from 2012 to 2014 (3,409, 3,321, and 2,138, respectfully for 2012, 2013 and 2014). 2015 final data will probably lie between the 2013 and 2014 data. The decline in the number of truckloads for 2014 is related to decreased staffing at the border stations and more trucks passing through when the stations were unmanned. Building more sustainable food resources for honey bees in California, and thus retaining more bees in California, was hindered by drought conditions.

Targeting an increase in planted acreage for honey bees was successful. From 2012-2013, more than sixty planted acres were made available as honey bee forage, supporting ten colonies per acre. During 2013-2014, 225 acres were planted, with well over 2,250 colonies within foraging range of this acreage. For the 2014-2015 planting season, 750 acres were planted benefitting 1,500 bee colonies directly, with many more colonies within foraging range of this acreage. All three regions, CR, SF and CV areas, contained plantings, with the majority of acres in the CV and in proximity to greatest bee populations in the state.

Targeting an extensive outreach campaign was successful. Fifty presentations were given over the course of the grant to an audience of over 4,427 individuals. Twelve thousand six-hundred and fifty trade show visitors saw or received information about the project. Growers and landowners were able to view several different types of honey bee forage in bloom at a field day. The field day was attended by fifty individuals. Eleven videos were produced with over 5,000 viewers watching these honey bee forage and nutrition videos. Scores of articles were written about this project discussing the benefits of providing honey bees sustainable, diverse, floral resources

There are numerous successful outcomes of this project and these outcomes far exceeded all expectations. First and foremost, this project yielded more than one low-moisture-requiring wildflower mix adapted for each of the three targeted regions, the CR, CV and SF. Over the three planting seasons of the project, a mustard mix, a clover mix, and a wildflower mix were refined and improved such that they are now widely used and requested. All three of these mixes plus vetch can be successfully grown in the CR, CV and SF regions and provide benefits to landowners while assisting honey bees. Over 750 acres of honey bee forage was planted in fall, 2014, and landowners and land managers are requesting seed to plant several thousand acres, if funding is available. Particularly successful was the use of mustards (including radish) as honey bee forage. Mustards are highly attractive to bees, provide a complete source of amino acids, have a relatively high crude protein content of 24%, build considerable organic matter in the soil, retain soil moisture, improve water infiltration, reduce soil erosion, suppress noxious weeds and can assist in nematode control. Not only will mustard provide excellent nutrition for honey bees, their dense flowering attracts many different native pollinators and other insects beneficial in biological pest control. Almond growers are pleased with the way mustards anchor honey bees in an orchard so that when almond bloom arrives, the bees are set to pollinate right there, without having wasted energy and flight time searching elsewhere for food. Almond growers with additional nutritional resources for bees become a preferred client of beekeepers. Mustards are incredibly cost-effective and at $30 per acre, are very affordable, given the advantages of their use.

Clover and vetch, post-almond bloom honey bee food resources, have many of the same soil-building advantages as mustard, and they also fix soil nitrogen. Balansa clover alone can fix as much as 100 pounds nitrogen per acre. Clovers are also cost-effective at $50 per acre.
Wildflower mixes can cost well over $300 per acre; however, a wildflower mix was developed for this project costing $125 per acre and thus more easily affordable for landowners.

Individual wildflower species were also evaluated. In a number of the smaller test plots, Phacelia ciliata proved to be a very early and long-blooming plant, highly attractive to honey bees. Data was gathered for a searchable online database, Honey Plants of California which will be found at http://ucanr.edu/sites/hpc/Honey_Plant_Reseach_Database/ and will be online in fall, 2015.

The emphasis on specialty oilseed crops brought national attention to the concept that landowners could plant nutritional sources for honey bees, followed by harvesting an oilseed crop, and thus receive a return on their investment in honey bee health. As targeted, three specialty oilseed crops are recommended for continued planting - canola, borage and meadowfoam. The best location for borage cultivation was the Sierra Foothills (SF). Canola acreage in the United States is far below that of Canada, and could become a much more prevalent crop in the United States and in California. Oregon State University is continuing work on borage and meadowfoam.

Beneficiaries

Beneficiaries of this project's numerous accomplishments include California's specialty crop producers who rely on bees to pollinate their fruit, nut, vegetable, herb, spice and seed crops and the commercial beekeepers who manage the honey bee colonies needed to pollinate California's specialty crop industry. These producers represent nearly fifty different crops with a farm gate value of approximately $8 billion. And, in particular, California's 6,000 and plus almond growers, who are 100% reliant upon honey bees to set their crops, directly benefit from improved honey bee colony strength made possible through improved honey bee nutrition. Nationwide, the direct and indirect contribution of honey bees in farm income is substantial; it is estimated at $20 billion. Better forage in California means better bees in California and less transporting of colonies to find out-of-state floral resources.

Growers, farmers, landowners and land managers benefit from building honey bee forage resources because improved forage equates to improved nutrition and insuring a more sustainable supply of honey bees. Most plant species planted provided the landowner with other ecosystem services; cover crops improved soil tilth, improved water infiltration, prevented erosion, added organic matter to the soils and with the legumes, fixed nitrogen in the soil.

Beekeepers benefit from building honey bee forage resources with healthier bees and decreased supplement feed costs. The nation's beekeepers, most of whom rely on pollination of California's specialty crops for operating income, endure tremendous costs for supplemental feed. Sugar syrups and high-fructose corn syrup, the most frequently used supplemental feeds, do not supply the proteins or amino acids necessary to support life. Single species crops provide little diversity in food. Planting diverse, nutritional resources for honey bees is imperative to sustaining a healthy population of these crop pollinators.

Additionally, the over 1,000 commercial beekeepers who manage the 1.8 million colonies needed to pollinate California's specialty crop industry are also direct beneficiaries of this project's accomplishments.

Lessons Learned

Perhaps the greatest lesson learned was that growers, farmers, landowners, and land managers are willing to help build nutritional resources for honey bees. Those that have fallow land, roadways, easements, young orchards, and even mature orchards can be enlisted to sow seeds for bees, provided they are given the encouragement and the horticultural guidelines for successful germination.

Improving honey bee nutrition is a land use issue. Optimizing landscapes to provide nectar and pollen sources for honey bees assists not only with honey production but also the over ninety different crops requiring bees for pollination. Fencerow to fencerow plantings of corn and soybeans that are nutritionally inferior to bee-attractive crops and plants has decreased available resources for bees, thus a concerted effort to increase pollinator plantings is imperative. Widespread use of the herbicide glyphosate (RoundUp) has decreased flowering weeds, once important for sustaining honey bee populations. Thus, deliberate plantings of honey bee forage are vital, not just for bees, but for numerous agricultural systems.

The preferred time to plant honey bee forage seeds in California is during the fall. October is probably the optimum month, provided germinating rains occur soon after planting, with additional moisture following in November and December. Seeds sown later in the fall, sometimes due to lack of precipitation, bloomed during almond bloom.

Whereas many of the plant species tested, and all of the recommended species, are low-moisture-requiring species, drought delays or inhibits germination. Critical to seed germination is the post-planting window of opportunity where, in pre-drought California conditions, normal precipitation is sufficient to germinate seed. During drought conditions, timing of the bloom period so important to honey bees may be delayed such that bees can face starvation. Delayed bloom for pre-almond bloom honey bee forage may force forage bloom to coincide with the crop bloom.

All plant species tested were adaptable to each of the three regions (CR, CV and SF), but timing of bloom differed by rainfall, temperature, and elevation. Bloom was delayed by lack of rain, unseasonably cold temperatures or frost, and higher elevations.

Native wildflowers are currently too cost-prohibitive to plant in the scale that is needed to make a significant impact on honey bee health. Hundreds of thousands of acres of honey bee forage are needed to support honey bee health. At over $300 per acre, native wildflowers will not be a cost effective avenue to meet the required needs of the 1.8 million colonies that now come to California for almond pollination.

Growers and farmers think large-scale, and consequently efforts to improve honey bee nutrition through planting flowering resources should be large-scale efforts. An acre of flowers here and there to help honey bees is not sufficient. In particular, asking growers and farmers to plant one acre when they are accustomed to farming hundreds of acres does not fit the farmer's mindset of today. If a grower is going to invest the effort to plant seeds, that grower will want to fill a farm-sized seed hopper. An additional lesson learned about these agricultural cooperators is that direct, personal phone communication is the most effective way to enlist their help in building honey bee forage. Using cell phone numbers and talking directly to the grower is considerably more effective than email means of communication. Certain types of growers do not own seeders or no-till drills for planting seeds, and an equipment rental opportunity exists to supply landowners with this equipment on a once per year basis only. Other economic incentives to encourage landowners to plant forage for honey bees would be valuable not only for the health of honey bees, but to insure sufficient supply of colonies for crop pollination, and for improving soil tilth. Development of greater acreage to honey bee forage should be tied into the objectives of other entities, agencies and organizations to encourage further adoption of the concept of helping honey bees through better nutrition.

Weed pressure can limit forage planting success. Where possible, soil preparation should include a regime for weed prevention that might include irrigation and then disking more than once to knock down weeds or using an herbicide prior to planting.

Beekeepers will allow their colonies to remain in California after almond pollination to take advantage of blooming honey bee forage. Honey bee colonies require continuous pollen and nectar sources. Before and after a target agricultural crop is pollinated, there is often a time of nutritional death for honey bees. Planted honey bee forage provides additional food resources before and after crop pollination, and beekeepers will work with landowners on the timing of transportation in and out of agricultural crops depending on bloom availability. A longer period of bloom helps sustain multiple generations of bees and allows more time between transports.

Efforts to increase honey bee forage acreage mitigates key honey bee stressors such as malnutrition, pest and disease pressures, shortened foraging activity, decreased lifespans of individual bees and dwindling colony sizes.

Implementing this project resulted in several unexpected outcomes. First, was the national exposure this California project has received. Even though results were presented at two or three national meetings per year, in addition to numerous regional and state meetings, the national recognition the project received was unexpected. Judging from the correspondence received, the nationwide honey bee community, as well as many grower groups, are aware of this project as are a surprising number of individuals in the larger public. Furthermore, this project serves as a model for many other pollinator habitat projects that have since been initiated. Because of this California project, Project Apis m. was asked by Pheasants Forever and Browning's Honey Company to undertake a similar project in the Upper Midwest in the near future, the second most important honey bee colony staging area next to California's agriculturally intense Central Valley. Bayer Corporation's involvement with Project Apis m. and their assistance in evaluating plant species at their Fresno Farm resulted in a partnership with McCarty Farms in Kansas. Overall visibility of this project exceeded expectations.

A second unexpected outcome was the increase in coordinated nutrition research by the USDA Agricultural Research Services (ARS) and several universities including University of California, Davis, California State University, Fresno, Oregon State University, Corvalis, Bayer Corporation, the Honey Bee Health Coalition, and several other organizations. Because of Project Apis m.'s notoriety due to the extent of this project, Project Apis m. representatives were key participants in forage and nutrition workshops held to benefit honey bee health. Project Apis m. was frequently asked to provide meeting and workshop participants with an overview of this project – as was the case with CDFA's Healthy Pollinator Working Group meeting held June 4, 2015.

Thirdly, the research conducted on bloom competition as a result of this project was unexpected. Growers of pollinated crops had some resistance to other honey bee forage resources blooming at the same time as their targeted crop. This led to actual research conducted on bee visitation in cover crops versus almond flowers. A grower-cooperator in the Fresno area (Bayer) found bees' visits to almond blooms were the same, regardless of the presence of cover crops or not. In fact, cover crops attracted bees to the orchard earlier in the day.

A fourth unexpected outcome was the ability to work with BIP on obtaining industry data on the first-ever comprehensive survey of supplemental feed costs for commercial beekeepers. Most commercial beekeepers spend about $24 per colony per year on supplemental feed. Conservatively figuring, with just over 2 million commercial colonies in the United States, feed approaches $50 million per year. Thus, there is justification to spend a few million dollars planting seeds for bees.

Fifth, due to the extent of outreach and the requests to provide presentations on honey bee forage nationwide, the notoriety of the project resulted in an invitation to the White House to provide input into the National

Strategy to Promote the Health of Honey Bees and Other Pollinators. The National Strategy now includes several elements to improve honey bee forage nationwide, including involving the top federal agencies and public-private partnerships. The National Strategy seeks to restore seven million acres of habitat in the next five years.

Additional Information

The Forage website tab can be found at http://projectapism.org/?page_id=72.
Forage Resources can be found at http://projectapism.org/?page_id=1413.
Forage Guidelines for almond growers can be found at http://projectapism.org/?page_id=1407.
Forage Videos can be found at http://projectapism.org/?page_id=245 and also by searching for Project Apis m. on YouTube.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 50	**Project Title:** Sensing Method for Rapid, Non-Destructive, Reliable Detection of Aflatoxin in Almonds	
Grant Recipient: University of California, Davis	**Grant Agreement No.:** SCB12050	**Date Submitted:** December 2015
Recipient Contact: Dr. David C. Slaughter	**Telephone:** 530-752-5553	**Email:** dcslaughter@ucdavis.edu

Project Summary

Almonds are an important crop to California, which had, for example, 840,000 acres of land used for growing almonds, a total nut production of 2 billion pounds with a total value of $5.8 billion in 2013 (National Agricultural Statistics Service, 2014). Between 2010 and 2013, almond production in the Americas accounted for 60.6% of the total world production, followed by Asia with 16.2%, Europe with 11.5%, and Africa with 7.8% (Food and Agricultural Organization of the United Nations, FAO, 2014). In the United States, California is the only state that produces almonds commercially. California almond production is currently exported to 90 countries worldwide, and approximately one third of California's almond crop is exported to the European Union (EU), which imposes very strict food quality standards (United States Department of Agriculture (USDA), 2014).

Aflatoxins (AF) are mycotoxins that can be produced in food commodities, like nuts, under certain conditions by the molds *Aspergillus flavus* (*A. flavus*) and *Aspergillus parasiticus* (*A. parasiticus*). The presence of AFs in food, even small amounts, is a concern as they can cause liver damage and cancer. The health problems caused by AF consumption can be acute or chronic; acute aflatoxicosis results in death and chronic aflatoxicosis results in cancer, immune system suppression, impaired child growth, and other pathological conditions (Newberne & Butler, 1969; International Agency for Research on Cancer (IARC), 2012. The occurrence of AF in almonds, beyond a permissible safe limit (the average level AF limit in a 1 pound bulk sample is 20 ppb in the USA, 10 ppb in the EU) is a concern for its trade, particularly to export markets. Detection of AF infested almonds in California is currently performed by destructive chemical analysis (i.e. samples are destroyed for the chemical analysis) on a random sample taken from a lot. However, the individual, kernel-to-kernel distribution of AF in a naturally contaminated lot is highly variable. For example, it was estimated that in a naturally contaminated lot of shelled corn, where the mean concentration of AF was 20 ppb, only 6 kernels in 10,000 are actually contaminated with AF (i.e., 99.94% are uncontaminated). Therefore, the existing destructive method is unreliable as AF distribution in the lot is highly heterogeneous and increased sampling is costly using the current, destructive method of AF analysis.

The objective of this project was to develop the fundamental knowledge of the optical characteristics of *Aspergillus* mold infested, and AF contaminated almonds in order to obtain a new method for rapid, non-destructive sensing of AF contamination in almonds using a modern sensing technique. The primary objective of this study was specifically to develop a new method to non-destructively distinguish individual, whole almond kernels infected with *A. flavus* or *A. parasiticus* from uninfected kernels in cases where there are not obvious visual external differences between them (i.e. undetectable by a normal color and defect sorter). The methodology and effectiveness of the new technique was published so future developers of in-

line almond sorters might incorporate this new knowledge in commercial equipment and provide a new rapid screening and management tool to help the almond industry maximize the marketability of the uncontaminated crop.

The project's findings provide an optimized, rapid and reliable method for detecting *Aspergillus* mold infested almond kernels and AF contamination in almonds that will be a valuable management tool for the ~6,000 California almond growers with ~810,000 bearing acres in the state. To meet customer demands, California almond growers have created a rigorous food safety program using nut pasteurization to reduce levels of unsafe bacteria and ensure safety. Since pasteurization does not eliminate AF in almonds, the proposed method for rapid detection of *Aspergillus* mold infection and AF contamination will help growers achieve the goal of quality and safety, and ensure domestic and international almond trade. This new screening tool is particularly beneficial since the EU has implemented a stringent mandatory AF testing program for almonds imported from the United States. As a non-destructive technique it can be used for sorting out contaminated almonds prior to shipment, reducing expenses incurred in rejected consignments (demurrage, warehousing, replacement expenses, with direct costs alone of ~$10,000 per event) and helping to maintain the quality and safety reputation and associated market value of California almonds.

The project's findings allow equipment manufacturers to develop new tools for almond growers to better manage crop sanitation, to reduce fungal contamination, and to maintain the high quality demanded by export markets. Currently over half a million pounds of almonds are destroyed annually for AF testing. Rapid, in-line detection of AF in almonds using this technique will save time, labor, and energy and testing costs, while helping the industry promote consumer health by providing safer nuts and foods made using almonds; which is particularly beneficial to children who are quite susceptible to adverse effects of AFs.

The project did not build on a previously funded Specialty Crop Block Grant Project.

Project Approach

A multi-year study was conducted to characterize the optical properties of whole, intact almond kernels in order to develop a new, rapid, non-destructive method of detecting kernels infected with *Aspergillus* mold or contaminated with AF, that are invisible to the human eye. For this purpose, bulk shelled nonpareil California almond kernels were collected from the 2012 and 2013 harvest seasons and obtained directly from local almond processing facilities in California. A total of 1,300 almond samples were manually selected from the bulk based on their size and appearance. Individual almonds that had no visible signs of damage or markings on the surface were manually selected from the bulk samples. This was done to simulate a clean and homogeneous product output by a standard color and defect sorter. The selected kernels were split into three groups randomly. One group was inoculated with *A. flavus,* one was inoculated with *A. parasiticus*, and the third remained free of contamination to be used as an uninfected control. The incubation periods of the infections were adjusted to achieve various levels of aflatoxins for use in the development of a machine capable method for automated detection. After the incubation period, all almonds (including the negative controls) were gently washed to remove conidia from the surface of inoculated kernels with special care in order to prevent damaging the skin of the almonds in order to produce a sample set where there were not obvious visual external differences between contaminated and control almonds.

Basic parameters of almond kernel samples were measured and recorded upon selection (from the bulk), such as weight, size, and color. All samples were then individually measured using non-destructive spectroscopic/optical methods, including UV fluorescence and visible and Near Infrared (NIR) reflectance before and after the inoculation process. A single, whole kernel interface was designed and fabricated for the visible and NIR instrument to allow non-contact measurements of each kernel. After the non-destructive measurements following the inoculation were completed, all kernels were analyzed using the conventional, destructive high-performance liquid chromatography (HPLC) method to determine the aflatoxin levels in individual kernels.

A complete statistical analysis and machine learning process was then conducted. Two different multivariate statistical models for detecting hidden mold effects and AF contamination were developed and evaluated. One model was designed to classify the condition of each almond and determine the probability that it belongs to the infected or uninfected class using the non-destructive reflectance data of individual almonds. Statistical validation using the aflatoxin results from the HPLC analysis confirms the classification concept and the model cross-validation showed over 99% accuracy with no false negative (i.e. no infected almond was classified as uninfected almond). The other approach taken to modeling was to predict the actual aflatoxin concentrations using the non-destructive reflectance data, and this model shows good performance with a high correlation between the predicted aflatoxin concentrations and its actual AF concentrations determined by HPLC. Upon further analysis of the models developed, it was discovered that the near infrared light absorption bands of lipids (i.e. fat) are important factors in discriminating infected kernels and in predicting aflatoxin concentration. This may be due to the high lipid content in the natural composition of almonds (fat content about 50%) or the specific aflatoxin biosynthesis and metabolism mechanism of the two *Aspergillus* species used in the project. This finding also means that only a small set of wavebands will be needed in order to discriminate or predict the contamination conditions effectively.

A non-destructive, rapid kernel scanning system, which allows two-dimensional spectral assessments across the surface of the whole kernels and provides information on the spatial distribution of the fungal infection across the surface of individual kernels, was designed, fabricated, and then evaluated in this project. The scanned images of almond kernels from the prototype were processed and analyzed using advanced multivariate statistical methods similar to the aforementioned modeling approach. The spatial distribution of the fungal infection across the surface of individual kernels was investigated. Results here showed that a single optical measurement of the whole kernel was sufficient for determining presence of fungal infection and aflatoxin contamination in almonds and that a high-spatial resolution model was not needed for good performance. Results also indicate that there is no specific spatial pattern or distribution to the aflatoxin concentrations within each kernel. These findings are important because they indicate that faster, less costly sensor technologies for optical reflectance measurements of the whole kernel as a unit are likely to be as effective as more costly, high spatial resolution scans across the surface of the kernel.

Both conclusions about the lipid bands and the spatial distribution of the infection contribute to the design criteria for industrial in-line scanning/sorting prototypes. This prototype design concept uses the smaller set of wavebands identified and measures one average spectrum per kernel. The statistical models built are then applied to the spectrum to determine if the kernel is contaminated. A scientific journal article that describes the scientific findings in this project was developed and has been published by the Biosystems Engineering journal and is available online. (See Additional Information) The scientific information can then be accessed by California specialty crops growers, the almond industry, and the manufacturers of almond sorting equipment.

The research contributions for this research project were provided solely by faculty, postdoctoral scholars and students of the University of California, Davis (UC Davis). Faculty and the postdoctoral scholar in the Biological and Agricultural Engineering Department provided technical expertise on all sensor development, instrumentation, statistical analysis and mathematical modeling for the almond infection status classifier and the prediction of aflatoxin contamination levels in individual almond kernels. Faculty and the postdoctoral scholar in the Plant Pathology Department provided scientific expertise on all microbiological, fungal pathogen infection, aflatoxin production and aflatoxin analysis aspects of the project.

Goals and Outcomes Achieved

A total of 1,300 almond samples were manually inoculated with *A. flavus* and *A. parasiticus* and each was measured or observed for its size, weight, color, UV fluorescence, visible and near infrared spectral reflectance. These data generated scientific knowledge that significantly improves the basic understanding of the optical properties of individual almond kernels contaminated with different levels and types of aflatoxins and fungal infections.

Multivariate statistical models for predicting the presence of hidden fungal contamination have been developed using the measurement data collected. The development of mathematical/statistical models and algorithms have found a smaller set of important near infrared wavebands that could discriminate the infected kernels and predict the AF concentration effectively.

These models then aided in the development of an advanced kernel scanning system. Results from the scanning system indicate that a single, average measurement of each almond kernel is sufficient in determining the condition of the infection in the whole kernel with good performance. These findings then contributed to the design concept for an industrial in-line scanning.

Individualized training of two postdoctoral scholars has been conducted. One postdoctoral scholar received training in state-of-the-art research techniques in plant pathology and the tools and methods used to study plant pathogens in specialty crops and the methods to control these pests. The second postdoctoral scholar received training in state-of-the-art research techniques in the design of rapid, non-destructive sensing technology and multivariate model development for non-destructive assessment of the internal quality of agricultural products.

The primary measurable outcomes are:

- The generation of scientific knowledge characterizing the optical properties (in the UV, visible and NIR) of contaminated almonds most useful in quantifying the AF level.

The goal was accomplished and significant amount of scientific knowledge was generated by measuring various optical properties of contaminated almonds. A scientific journal paper was published documenting this new knowledge and providing public access to the findings.

- Multivariate mathematical models, using modern sensor fusion techniques, for determination of AF content.

  The goal was accomplished and several multivariate mathematical models were developed using the measurements made to identify infected kernels and determine the AF levels. A scientific journal paper was published documenting the performance of the model to detect fungal infection in individual almond kernels. (See Additional Information)

- A prototype rapid, non-destructive detection system for AF contamination in individual almond kernels.

  A prototype rapid, non-destructive detection system of AF contamination in individual kernels was developed and tested at UC Davis. The performance and data analysis of this research prototype led to the design recommendation for the concept of a commercial prototype for rapid, non-destructive screening of all almond kernels for hidden fungal infection and aflatoxin accomplishing this goal.

- State-of-the-art training of two Postdoctoral Scholars as future researchers to help develop new tools to detect, eradicate and control pests and diseases in specialty crops.

  The goal was accomplished and the training of the two Postdoctoral Scholars was completed.

Baseline optical data was collected on over 1,300 almond kernels and the results show that there were clear differences between infected and uninfected almonds in the NIR region of the spectra (800 – 2500 nm). Figure 1 shows A) absorbance and B) second derivative of absorbance spectra (calculated from the reflectance spectra measured using the laboratory-grade spectrometer) of the infected (red solid line) and uninfected (blue dashed line) almonds. The figures provide a basic idea of where the larger differences are in terms of wavelengths (i.e. different colors and shades of near infrared light; x-axes) between the infected and uninfected almonds.

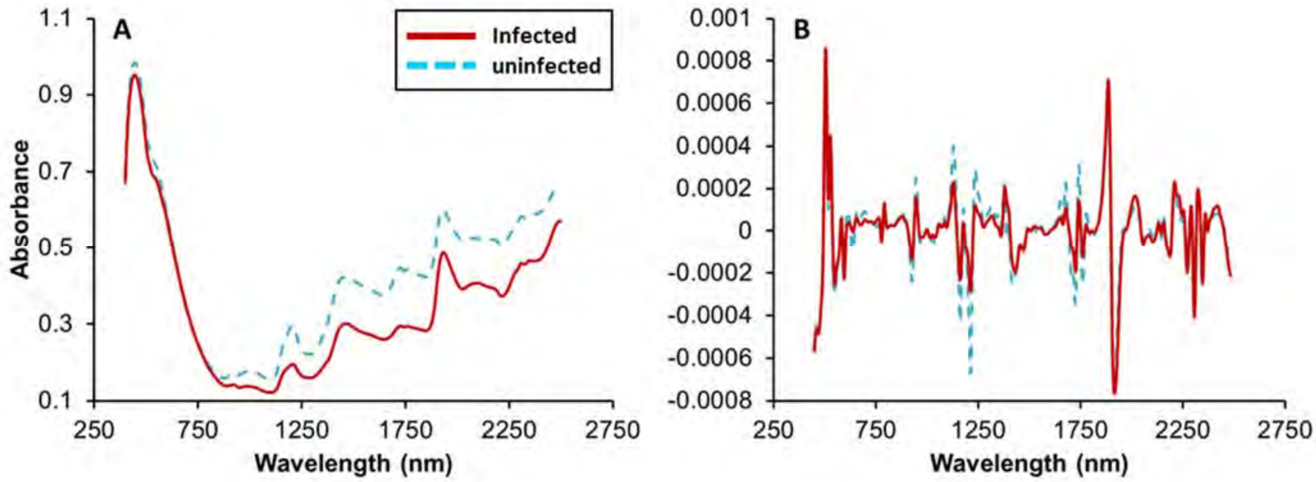


Figure. 1.

By applying multivariate statistical modeling techniques, the project team was able to first discriminate the two groups (i.e. infected from uninfected). The performance of the classifying method is illustrated in Figure 2. This frequency plot shows the distribution of the infected (red solid bars) and uninfected (blue pattern bars) almonds on the canonical discriminant function. The two peaks are clearly separated, which indicates that the classifier developed in the project was very effective in discriminating almonds with hidden fungal infection from uninfected control kernels.

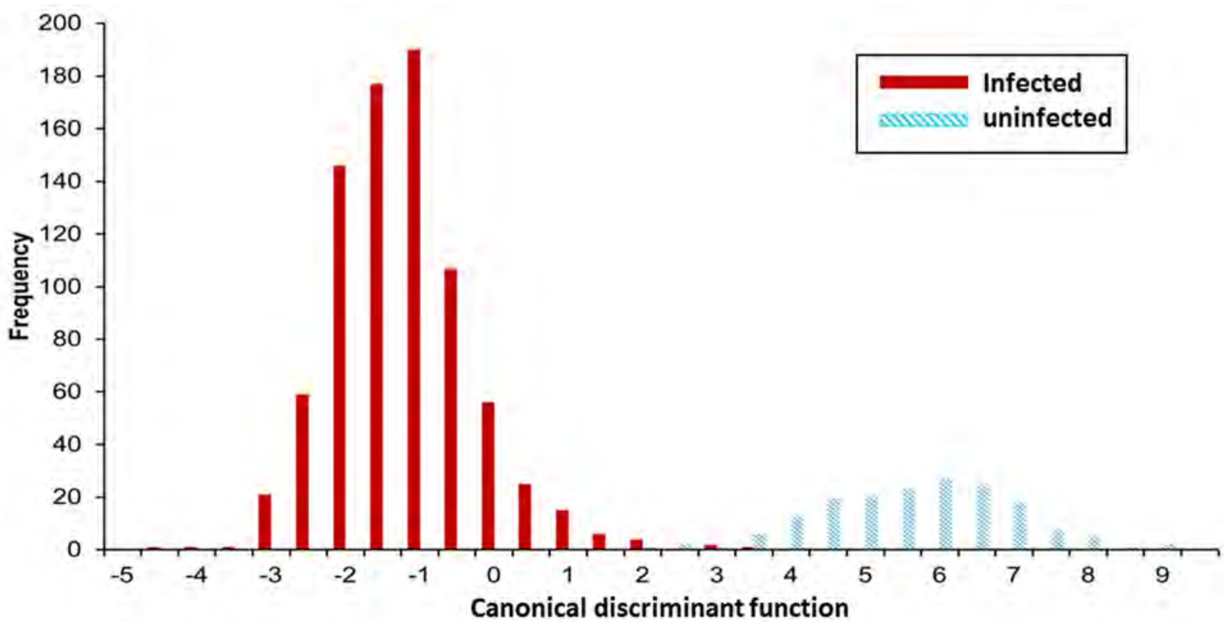


Figure. 2.

A second multivariate statistical modeling approach was implemented to predict aflatoxin concentrations in individual kernels, without damaging the kernels. Figure 3 shows the correlation between the true aflatoxin concentration determined by the conventional destructive HPLC method and the predicted values from the model built based on spectral reflectance data, measured non-destructively on individual, whole kernels. As illustrated by the figure, a very high level of linear association (R-square value of 0.933) was obtained and the high correlation indicates the good performance of the predictive model in determining the AF levels in individual almond kernels using NIR reflectance spectra. Unlike the current method, which is destructive and only provides an estimate of the average aflatoxin level in a large bulk sample of hundreds of nuts, this new method is non-destructive, and predicts the aflatoxin level in each kernel individually. Further, as a high-speed, non-contact method it is suited for in-line sorting to remove only the infect kernels while retaining the good kernels from the remainder of the lot.

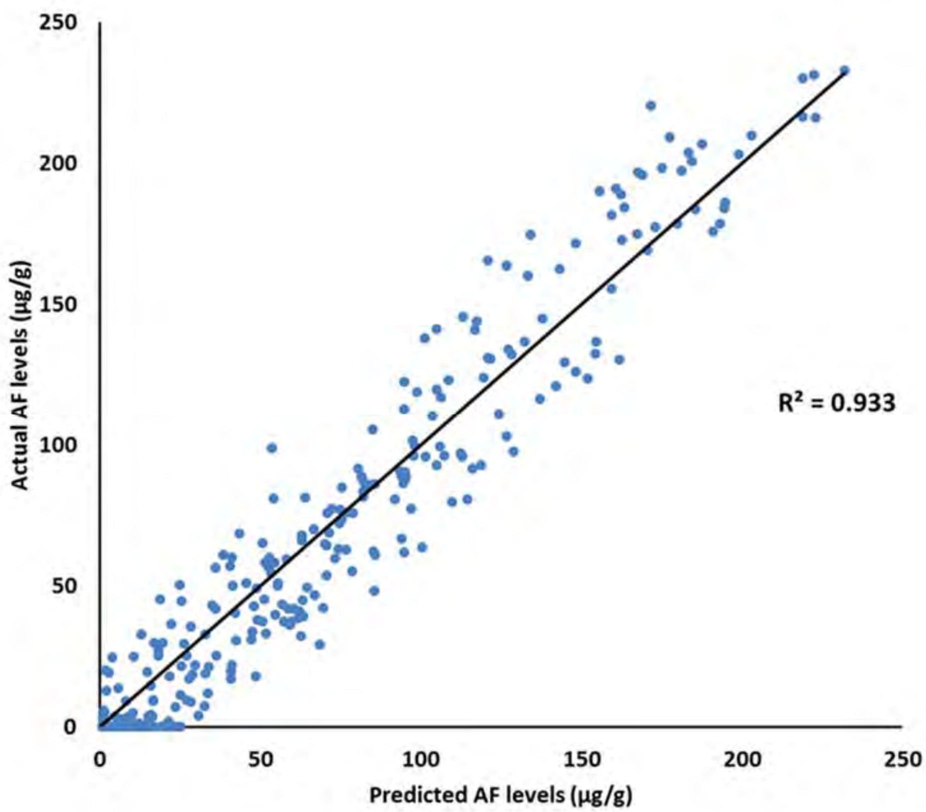


Figure. 3.

From the model development process, a smaller set of wavelengths were identified and it was discovered that these wavelengths were mostly near infrared light absorption bands associated with lipids in the nuts. This provides some insight into the mechanism of *A. flavus* and *A. parasiticus* metabolism and also this smaller set of wavelengths that are most important in designing a prototype system to scan almonds for AF.

A non-destructive, rapid scanning, hyperspectral imaging (HSI) system, was also developed in this project to scan across the entire surface of whole kernels and provide high-resolution spatial information of the infection/contamination of the kernels. The HSI system consists of an optical spectrograph in conjunction with a digital camera, four halogen lamps contained in two specially designed illumination guides, two step motor positioning devices for transporting the nuts and adjusting the camera, a digital encoder readout, and a mounting framework. The system was designed to automatically move the almond kernels on a step motor platform under the camera lens and to capture multiple hyperspectral images that can, when combined with a statistical model, provide information about the infection spatially and instantly. After processing of these images, there is one 2D spatial image at each wavelength for each kernel. The intensity/brightness of each pixel then indicates the reflectance at that wavelength and location on the kernel. As illustrated in Figure 4, this results in an “image cube” that provides a full spectra at each pixel on the surface of the almond in the image.

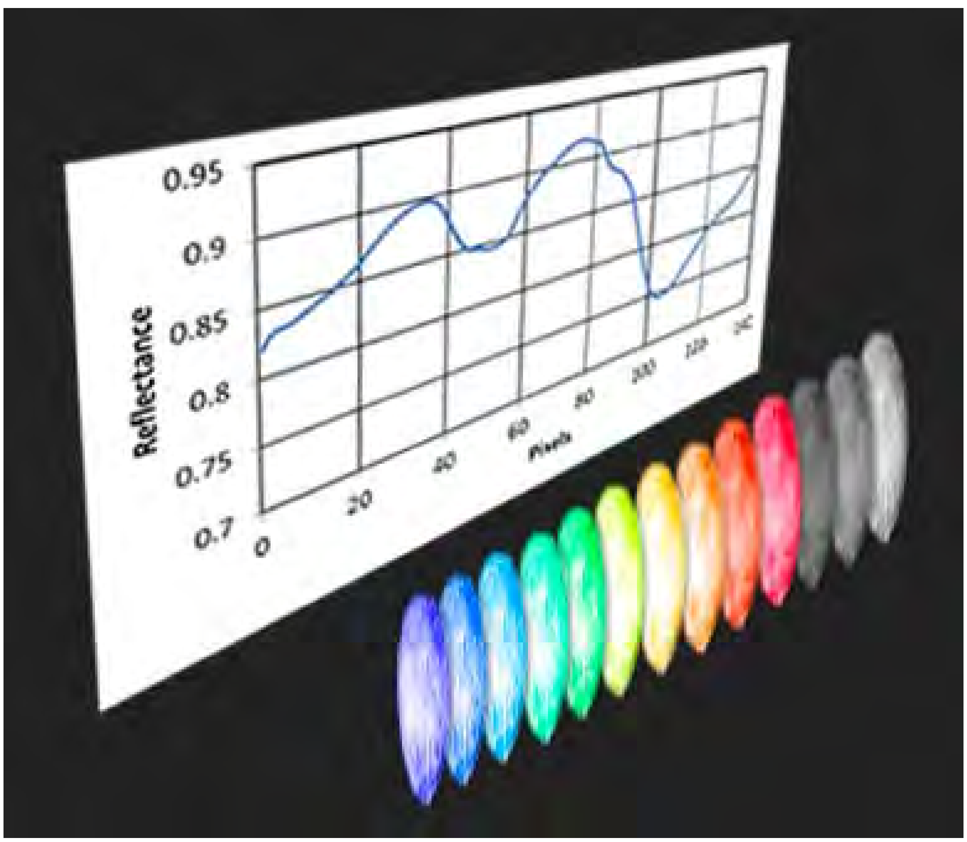


Figure. 4.

The results from the HSI system indicates that a single optical measurement of the whole kernel was sufficient for determining the presence of fungal infection and aflatoxin contamination in almonds and that a high-spatial resolution model was not needed for good performance. These findings then contribute to the knowledge needed in the design of the prototype non-destructive detection system for AF contamination in individual almond kernels and the design concept of a commercial sorter that utilizes faster, less costly sensor technologies than the HSI for optical reflectance measurements of the whole kernel as a unit was then developed (Figure 5).

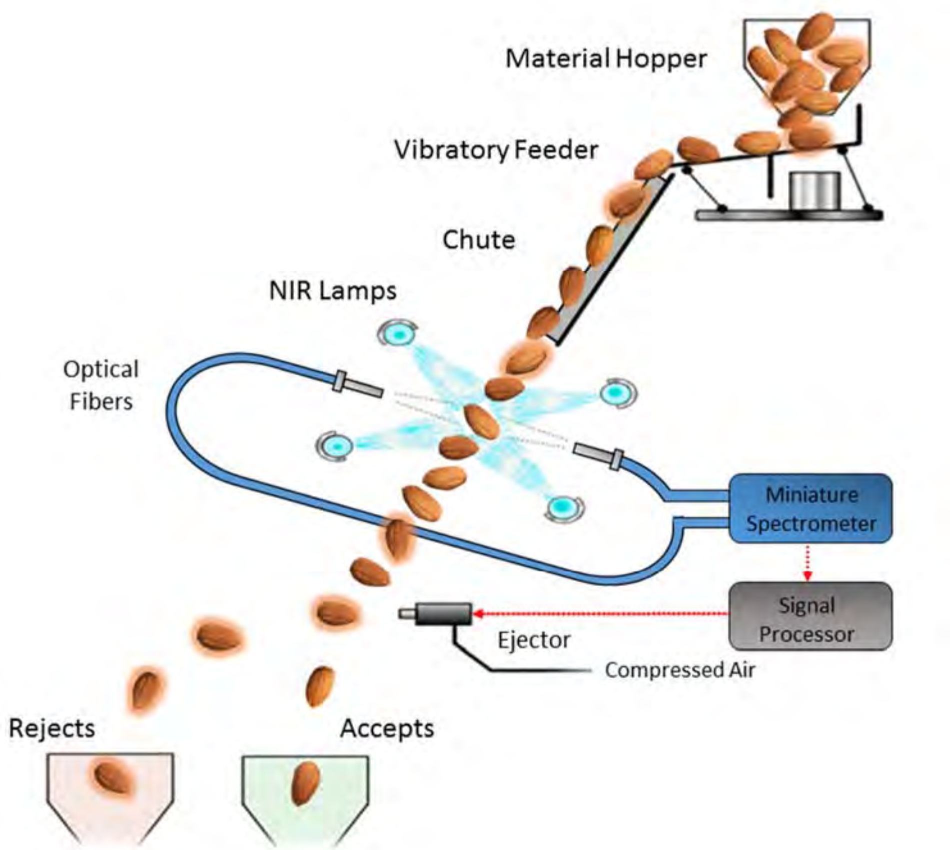


Figure.5.

The design concept for the sorter prototype uses the lipid wavebands identified during the statistical model building process and the spectrometer collects one average spectral reading per kernel as it travels through the chute. The spectral reading is then processed using the predictive model developed to determine if the kernel is contaminated. When a contaminated kernel is detected, the compressed air removes the contaminated kernel from the stream.

Two multivariate statistical models were built with high degree of success. The first model was developed to discriminate infected kernels from the uninfected ones and achieved a 99% classification accuracy and zero false negatives (i.e. no infected kernels were classified as uninfected ones). The second model was developed to predict the actual AF concentration in individual kernels, and the predicted values agree with the actual values determined by conventional destructive method very well, with a coefficient of determination of r^2 = 0.93 (i.e. 93% of the variation in AF level in individual kernels was explained by the model).

Beneficiaries

The more than 6,000 California almond growers, 100 almond handlers and others working in the almond industry in California will benefit directly from the project's accomplishments. These groups work to increase almond production efficiency, improve almond quality, and develop environmentally responsible orchard and pest management practices. In addition, consumers of California almonds will also benefit from this project's accomplishments because the new method developed allows the automatic, non-destructive inspection of all almond kernels, rather than the current destructive method that is only conducted on a tiny fraction of the crop.

Lessons Learned

Project success benefitted from the use of a multidisciplinary team of engineers and plant pathologists. The use of a multidisciplinary team was important to finding successful solutions to complex problems involving both aspects of biological science as well as technological development.

Previous research done on the detection of fungal infected corn kernels has suggested that starch and protein are the most critical compounds and the wavebands associated with these compound are important indicators in identifying contaminated kernels. It was thus unexpected that the results suggested that, for almonds, the lipid absorption bands are the most important features in the predictive model for AF contamination in almonds.

Additional Information

A scientific journal article that describes the scientific findings in this project has been published by the Biosystems Engineering journal and is available online at:
http://www.sciencedirect.com/science/article/pii/S1537511015001257

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 51	**Project Title:** Improved diagnostics for *Phytophthora* plant pathogens important to California agriculture	
Grant Recipient: U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS)	**Grant Agreement No.:** SCB12051	**Date Submitted:** December 2015
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Project Summary

Plant pathogens in the genus *Phytophthora* have a significant impact on a wide range of California specialty crops either by their direct effect on plant health and yield reductions or indirectly with regulatory restrictions on the movement/shipment of plant material intended to prevent pathogen introduction or spread (exemplified by the impact of regulatory requirements on the nursery industry due to *P. ramorum*). There are currently approximately 125 described species in the genus and dozens of taxa in the process of being formally described with a number of specialty crops grown in California (including ornamentals, strawberry and orchard crops such as avocado, citrus, almond, walnut, grape and pistachio) susceptible to at least one of them. Current detection techniques do not adequately fulfill the need for sensitive, accurate, rapid and cost effective detection of these pathogens, which hinders efforts at disease management. This proposal will address this by expanding on molecular detection of *Phytophthora* spp. using TaqMan real time Polymerase chain reaction (PCR) to include next generation techniques that will require less technological sophistication, be able to be done by technicians with less training and will be much less expensive to run. The marker system will be able to detect if any *Phytophthora* species are present in the sample as well as individual species of importance to California agricultural production. The California Department of Food and Agriculture (CDFA) Plant Pest Diagnostic Center will be a partner in this project to allow validation of the techniques with real-world plant samples and ensure technology transfer while the World Oomycete Genetic Resource Collection will contribute expertise with the genus and DNA samples representing all described species from diverse geographic areas to validate marker specificity. Techniques and supporting data will also be posted on an established website www.phytophthoradb.org to facilitate technology transfer to a wider audience.

Crop losses due to *Phytophthora* species can be significant and with their broad host range among California specialty crops, this can have a meaningful impact on the economics of production. Fungicide application can be an important control option in some cropping systems, but pathogen detection capabilities are important for timing applications. Also, fungicide control is not always feasible or effective with field grown crops and highlights a need for ensuring nursery plants are *Phytophthora* free prior to transplanting. This is particularly important in perennial crops where tree decline and death caused by *Phytophthora* can represent a significant loss on investment to the orchard grower. The ability to identify *Phytophthora* species should improve management capabilities, which in turn should increase profitability and competitiveness.

This project does not build upon a previously funded Specialty Crop Block Grant Program project.

Project Approach

- Evaluate different isothermal amplification techniques to determine which technology has the most potential to attain project objectives - The recombinant polymerase amplification (RPA) technique was found to work very well for the detection of *Phytophthora* from plant tissue and was selected to be the focus of this project.
- Develop genus specific detection capability with selected technique - Using the same regions of the mitochondrial genome that were used for the TaqMan real time PCR assay (Phytopathology 104: 733-748) a *Phytophthora* genus specific RPA diagnostic assay was developed that is highly specific for all *Phytophthora* species but will not amplify related genera or plants.
- Evaluate technique with environmental samples - a total of 222 plant samples from commercial production fields and nurseries (ornamental, avocado, strawberry, citrus, raspberry, etc.) were evaluated by culture, RPA genus specific and species specific RPA detection and our previously published TaqMan real time PCR assay to determine what *Phytophthora* species were present. The RPA assay consistently provided accurate determinations of the presence of *Phytophthora*.
- Work with optimization of technique for in-field diagnostics
- Several tissue extraction buffers were evaluated to identify the type that provided optimum potential for detection
- Techniques were developed for effective maceration of plant tissue in the field
- Methods using portable equipment for running the assay directly in the field were developed
- The primary limiting factor for using this technology directly in the field is how to collect the fluorescent data the assay generates when a positive reaction is obtained. A European company produces a portable unit but it is expensive. The project team has been working with a company in Hawaii that produces a portable low cost unit called Smart Dart. Although it was developed for another type of isothermal assay that runs at a much higher temperature (LAMP assay) and the team was able to use it for running our RPA assay. The project team has been working with the company to optimize the hardware/software for use with the RPA procedures. The current unit is approximately 5 times the size of a deck of cards, has an internal battery, and is run by an app on a smart phone via a Bluetooth connection.
- Attend workshop and conference to disseminate research results and collaborate with other researchers
- The technology was transferred to the CDFA diagnostic lab in Sacramento as well as collaborators at the University of California Riverside, Oregon State University, Michigan State University, and the USDA-APHIS-PPQ-CPHST lab in Beltsville, MD. Also transferred the technology to the Monterey County UC Cooperative Extension plant pathology lab and co-wrote a grant to the California Strawberry Commission that funded purchasing equipment and kits for their use of the assays for addressing the diagnostic needs of the strawberry industry. Have been contacted by a commercial avocado and citrus nursery requesting help setting their diagnostic lab up with the technology.

The current set up for using the RPA diagnostic assays developed in this project require ordering primers and probes, making the appropriate dilutions, and adding them to the amplification mixture just prior to use. While this is fine for a research lab it does place limitations on broad scale use by commercial crop producers. In an effort to simplify the process and make it more available for others to use the project team worked with the company that produces the RPA kits (TwistDx, UK) to include the primers and probes in the kit so the end user would have all items necessary. A test batch was produced for the project team and the kits worked the same as when the team added the primers/probes in the lab. The project team has proposed a project where a larger scale production would be done and used in a multi lab field validation project.

- Develop species-specific isothermal detection - species specific RPA assays were developed and validated for 7 species using DNA isolated form 136 *Phytophthora* taxa. This demonstrated a high degree of specificity for these markers.
- Species specific assays were validated for *P. ramorum, P. kernoviae, P. cinnamomi, P. fragariae, P. rubi, P. cactorum* and *P. tentaculata* (this is an invasive species that was recently introduced into the California native plant commercial nursery system).
- Developed the RPA assay for detection of Phytophthora species for 6 species and provided technical support for the development of markers for an additional 3 species. Based on the DNA sequence data collected, the project team designed, but did not test, RPA markers for a wide range of species so others working in the area could evaluate them if the need arose.
- Supported the validation of species specific detection of *P. sojae* and *P. sansomeana* with collaborators at Michigan State University.
- Putative primers for species specific detection for a number of other *Phytophthora* species were designed and made available in a supplementary file of the published manuscript for others to use (Miles et al. 2015).
- Validate species-specificity with environmental samples - a total of 222 plant samples from commercial production fields and nurseries (ornamental, avocado, strawberry, citrus, raspberry, etc.) were evaluated by culture, RPA genus specific, species specific RPA detection, and the previously published TaqMan real time PCR assay to determine what *Phytophthora* species were present. The RPA assay consistently provided accurate determinations of the presence of *Phytophthora*.

Completed research in addition to work plan:

- Additional research completed for RPA isothermal detection
- A major advantage of the RPA technology is two different detection assays can be run at the same time if different fluorescent labels are used. To provide an internal control to confirm that amplification is possible for each sample a primer pair and probe for amplification of a plant marker was developed and optimize so it could be run simultaneously with the pathogen detection assay.
- From a regulatory stand point it is important to be able to confirm the identification of a species when the assay has a positive result. To provide the ability to do this a technique was developed for confirming the identification of a genus specific positive amplification by using PCR to amplify a sequencing template directly from the RPA amplification mixture and sending it in for DNA sequencing. A database of over 850 sequences representing 136 *Phytophthora* taxa is available to use for identifying an unknown to a species level.
- Improvements were made to the real time PCR TaqMan assay (indicated in the proposal that as time allowed additional work on this marker system would be done).
- Genus specific amplification primers were redesigned to improve the efficiency of amplification for all species and were validated using 136 *Phytophthora* taxa (and did not amplify template from the common related genus *Pythium*, plants or true fungi).
- Specific primers for detection of an additional 35 species (many of these are of regulatory concern as invasive species) were validated against isolates representing 136 *Phytophthora* taxa.
- An expanded list of putative new species specific markers was pulled together so others would have a starting point for testing additional species specific markers we had not had a chance to validate. From

review of the data it appears likely that species specific markers could be systematically developed for at least 85% of the taxa included on our validation.

- A technique was developed for identification of multiple species when both are present in infected plants by amplifying with the genus specific primers, cutting the amplicon with a restriction enzyme and determining the size of the fragments by separating them by running on an agarose gel. While this approach is effective for many common species a more comprehensive and accurate method is to label the amplification primers with different fluorescent dyes, digest with a restriction enzyme and separate the terminal fragments on a DNA sequencing unit. This approach will allow for a far more precise determination of fragment size and accurate identification of nearly all species that may be present in a sample.
- Several tests were conducted in an effort to evaluate how well the real time PCR technique worked when different brands of real time PCR thermal cyclers are used and what parts of the procedures may need to be modified when transferring the technology to other labs. The technique was validated using two different models of thermal cyclers at the location and transferred all the technology to our cooperator's lab in Canada where they tested it on three other types of thermal cyclers. In all cases the procedure worked as expected.
- The region of the mitochondrial genome that is used for identification of *Phytophthora* isolates to a species level is the noncoding region between the *atp9-nad9* genes. This gene order is highly conserved in all *Phytophthora* species but *P. frigida* and *P. bisheria* had a mutation that altered this gene order. In an effort to modify the marker system so it would detect these species the genomes were sequenced with Illumina MiSeq and the mitochondrial genomes assembled. The gene downstream from the *atp9* gene was identified and a new reverse primer and species specific probe are under evaluation for detection of these two species.

Species in the genus *Phytophthora* have a broad host range but the work on this project was strictly focused on addressing the needs of the specialty crop industry.

The collaborators who helped conduct the lab work did an excellent job of independently confirming the accuracy and sensitivity of the assay developed by the PI. In addition, the collaborators also helped confirm the ability of multiple real time PCR platforms can be used to run the assay by testing 2 brands of equipment different from that available in the lab.

Goals and Outcomes Achieved

Activities that were performed to reach the project goals and outcomes were: primers and probes for *Phytophthora* genus and species specific detection with the RPA assay were designed and validated. Sequence alignments of the *atp9-nad9* region were evaluated for design of additional TaqMan real time PCR probes. The projects long term goals were to provide producers and diagnosticians with an easy to use tool for detecting *Phytophthora* at both a genus a species specific level. While the current status of the project provides an effective means for doing this the need for having to order primers and probes, dilute them to the appropriate concentrations and add them to the amplification mixture just prior to use limits the availability of the assay. The project team has been and will continue to work with the company that produces the RPA technology in an effort to make pre-formulated kits with primers and probes already incorporated in the reaction mixture available. Additional activities are mentioned below:

- Evaluate different isothermal amplification techniques to determine which technology has the most potential to attain project objectives - completed
- Develop genus specific detection capability with selected technique - completed
- Evaluate technique with environmental samples - completed
- Work with optimization of technique for in-field diagnostics - completed
- Attend workshop and conference to disseminate research results and collaborate with other researchers - completed
- Develop species-specific isothermal detection - completed
- Validate species-specificity with environmental samples - completed
- As time allows develop additional species specific TaqMan real time PCR assays - completed (exceeded)

Baseline data that has been gathered to date and showing the progress toward achieving set targets:

- *Phytophthora* genus specific RPA detection has been confirmed with 155 isolates representing 136 *Phytophthora* taxa
- Working with a company that produces a portable data collecting unit to optimize its capability for running RPA assays.
- Working with the company that produces the RPA technology to develop kits incorporating primers and probes needed for conducting these assays to make the assay more widely available to end users.
- *Phytophthora* species specific RPA detection has been confirmed with 9 species and putative primers to enable specific detection of a wide range of additional species have been designed.
- Techniques have been developed for identification of unknown isolates by DNA sequence analysis of the genus specific amplicon generated by the RPA assay without the need for DNA extraction.
- The designed RPA assays for *Phytophthora* provide a truly portable diagnostic tool that can be deployed directly in the field and yield results in as little as 15 minutes without the need for DNA extraction and a sensitivity nearly the same as TaqMan real time PCR (the current gold standard for molecular diagnostics).
- *Phytophthora* species specific detection by TaqMan real time PCR has been validated for an additional 35 species (for a total of 50 when prior work is included).
- Techniques were developed for isolate identification when multiple species are present in the same sample
- Both technologies has been transferred to six collaborating labs

Beneficiaries

Due to the large number of species in the genus *Phytophthora* and the wide host range across California specialty crops, the ability to improve disease management will have a significant impact on enhanced productivity for a wide range of crops. For example, a number of annual crops, including strawberry, tomato and pepper (crop value over $3.4 billion), and many perennial fruit and nut tree crops, such as avocado, citrus, almond, walnut, grape and pistachio (crop value over $9.9 billion), are susceptible to diseases caused by *Phytophthora*. The availability of improved and less expensive diagnostic techniques at a nursery level would reduce the potential for distribution of infected plant material into production fields as well as improve management of disease in ornamental production systems. This could be particularly important for fruit and nut tree crops as having to replace dead or less productive diseased trees represents a significant economic loss on investment to the grower.

Improved diagnostic capabilities would also support the export market of plant material (i.e.: strawberry) by addressing regulatory concerns of importing countries concerning pathogen movement. According to the California Strawberry Commission California is the nation's leading producer of strawberries. In 2014, more than 2.3 billion pounds of strawberries were harvested. That amounts to 88 percent of the country's total fresh and frozen strawberries. The value of the California strawberry crop is approximately $2.6 billion. Strawberries are the fifth most valuable fruit crop produced in California and this projects objectives of disease management would directly benefit California Strawberry growers. The disease management techniques from this project would have the ability to identify the pathogen to a species level, which is important for assessing risk and development of the management strategies for specialty crops. The availability of these techniques for field use would also improve the ability of growers to time fungicide applications early on during an epidemic where they would be more effective in controlling disease.

According to the California Avocado Commission in 2014, avocado growers in 5 major counties assessed the acreage in production to be roughly 51,478 avocado acres in California. Please see this link: http://www.californiaavocadogrowers.com/industry/acreage-inventory-summaries. These avocado acreages which could directly benefit from the work done in this project.

Furthermore, the ability to rapidly detect and identify invasive species not present in California is essential for preventing their introduction or limiting their spread and potential effects on California agriculture commodities. Having field based diagnostic techniques that are less expensive than current technologies and require less specialized labor would also reduce the cost associated with supporting quarantine management efforts and broaden their utility for production agriculture.

Lessons Learned

An unexpected outcome for this project was using comparative genomics of the mitochondrial genome to identify regions that will enable a systematic development of diagnostic markers is a useful approach. The RPA isothermal technology will provide an effective field diagnostic technology.

Additional Information

The following presentations were given at meetings to make others aware of our work:
February 20, 2014 - Met with CDFA in Sacramento to give demonstration for diagnosticians/ Plant Pathologists

- March 11, 2014 **-** Oral presentation: 60th Conference on Soilborne Plant Pathogens**.** Title: Rapid detection of *Phytophthora* species on plant samples using recombinase polymerase amplification.

- April 10, 2014 **-** Field demonstration of RPA: Driscoll's Inc.

- August 9-13, 2014 **-** Oral presentation: 2014 APS-CPS Joint Meeting, Minneapolis MN**.** Title: Rapid isothermal detection and species-specific assays of *Phytophthora* in plant samples using recombinase polymerase amplification.

- August 9-13, 2014 **-** Poster presentation: 2014 APS-CPS Joint Meeting, Minneapolis MN**.** Title: Validation of a TaqMan diagnostic assay for the systematic development of Phytophthora genus and species-specific markers

- March 14-15, 2015 **-** Oral presentation: Oomycete Molecular Genetics Network Meeting, Pacific Grove CA**.** Title: Mitochondrial marker systems for studying *Phytophthora* and *Pythium* for community analysis

- March 20, 2015 **-** Field demonstration of RPA at the California Avocado Commission's Field Day

- June 10-12, 2015 **-** Phytophthora detection workshop, North Central APS Meeting

- August 1-5, 2015 **-** Oral presentation: 2015 Annual APS Meeting, Pasadena CA**.** Title: Systematic development of species-specific assays for important *Phytophthora* spp. using recombinase polymerase amplification

- Oral presentation: 2015 Annual APS Meeting, Pasadena CA. Title: New advances in molecular diagnostics for *Phytophthora tentaculata*

- Poster presentation: 2015 Annual APS Meeting, Pasadena CA. Title: A systematic approach to develop species-specific markers for Phytophthora spp. using a mitochondrial locus

- Miles, T., Martin, F.N. and Coffey, M.D. 2015. Development of rapid isothermal amplification assays for detection of *Phytophthora* species in plant tissue. Phytopathology 105:265-278.
- Additional manuscripts describing the completed research are in preparation
  - validation of additional RPA assays
  - validation of additional real time PCR species specific TaqMan probes
  - techniques for using the genus specific amplicon for identification of isolates when multiple species are present (digestion with restriction enzymes and separating fragments on a DNA sequencer)

In addition, the diagnostics section of the *Phytophthora* Database www.phytophthoradb.org includes a section on the research completed by this project to more effectively transfer the technology to other labs.

California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.: 52	Project Title: Developing Integrated Pest Management Programs in Mint Emphasizing Biopesticides to Improve Crop Profitability and Sustainability	
Grant Recipient: The Regents of the University of California, Davis	**Grant Agreement No.:** SCB12052	**Date Submitted:** December 2015
Recipient Contact: Larry Godfrey	**Telephone:** (530) 752-1537	**Email:** ldgodfrey@ucdavis.edu

Project Summary

Peppermint, a specialty crop, is valued at approximately $7 million annually and is grown in the northeastern California counties of Shasta, Lassen, and Siskiyou. Peppermint leaves are traditionally used for herbal tea, but is also used for essential oil for personal care products and other flavoring industries. The major pests of peppermint in this area are two-spotted spider mites (TSM), the immature stages of mint root borer (MRB), mint flea beetles (MFB), and strawberry root weevils (SRW). All motile life stages of mites feed on peppermint leaves, while the immature stages of root-feeding insects feed on rootlets and rhizomes. Economic loss is as a result of decreased oil yield and quality, as well as reduced productive expectancy of mint stands. For pest management, most mint producers have historically relied on old chemistries, particularly organophosphate insecticides (chlorpyrifos, ethoprop, and acephate) to manage economic populations. This is especially problematic in these mint production areas given the sensitivity of their environments and watersheds to insecticide contamination. Biopesticides such as neem oil and Bacillus thuringiensis (Bt) can effectively control TSM and MRB and have no known adverse impact on the environment. Similarly, there are several biopesticides available in the marketplace. If proved to be effective on key mite pests and registered for peppermint, use of biopesticides in combination with conventional and new reduced-risk pesticides have the potential to improve the sustainability and profitability of mint. The objectives of this project were to 1) Evaluate the efficacy of the commercially available and experimental biopesticides against TSM in peppermint so that relatively low-risk product(s) for non-targets and the environment can be recommended for integrated pest management (IPM); 2) Determine the relationship between TSM damage and reduction in mint oil yield and quality; and 3) Evaluate the efficacy of registered and experimental reduced-risk insecticides and biopesticides against root-feeding insects (MRB, MFB, and SRW) in peppermint.

This project is important to ultimately reduce the usage of high-risk pesticides in peppermint and protect the quality of the environment in which mint is grown. This project is in agreement with the statewide priority for IPM-based pest management in order to reduce the impact of high-risk chemical pesticides on human health and the environment. Project staff aimed to explore some pesticide alternatives, including use of reduced-risk insecticides and use of biopesticides for mint arthropod pest management.

This project built on previously funded 2009 Specialty Crop Block Grant Program Project 47: *Refined Management of Arthropod Pests of Mint to Improve Sustainability and Protect Water Quality*, which facilitated the adoption of chlorantraniliprole, a reduced-risk insecticide, on mint production in four targeted counties, Shasta, Lassen, Modoc, and Siskiyou. With the aim of further improving the management tactics following IPM, the goal of the currently completed project was to test potential biopesticides for pest management and encourage growers to use less harmful pest management options. In this regard, this project is complementary to the previous project.

Project Approach

2012-2013:

Mint fields are in a winter dormancy from ~October to May. The primary period of concern from insects and mites in mint is from June to August. Therefore, the field aspects of this project started in the spring, 2013. During this period, monitoring for TSM, MFB, SRW, and MRB was conducted in growers' fields and the plots at the University of California Agriculture and Natural Resources Intermountain Research and Extension Center (IREC) in Tulelake, California. The overall pest population was moderate. Monitoring of TSM occurred from early June to early September 2013. Periodic sampling of soil and rhizomes was conducted for MFB and SRW populations during summer and fall 2013. MRB was monitored from mid-June through late-August 2013 using large delta sticky traps baited with MRB sex pheromone.

The number of TSM in experimental plots remained below action threshold (i.e., 5 mites/leaf) throughout the season. Traps were deployed in June and flight of MRB in 2013 began on July 1, and flight ended in late-August; peak moth flight occurred in mid-July, similar to 2010 and 2011. Moth capture was greater than in previous years, and similar in flight duration. These results could provide peppermint growers with a tool to monitor the MRB population and to use control options effectively against MRB.

In an experiment targeting TSM control, the biopesticide PFR-97 and the botanical pesticide Requiem® did not perform well in comparison to the conventional miticide products. From an experiment targeting the root feeding insects, the rhizome damage by MRB larvae indicated that the reduced risk insecticide Coragen® applied at the estimated peak flight reduced rhizome damage most effectively.

Project staff were unable to conduct one project activity "Evaluate soil-applied Bt effectiveness against MRB using laboratory bioassays" because of the technical difficulty in rearing MRB in the lab and unavailability of the insect commercially for studies. However, that activity was a preliminary step, but not required for the field experiments which were accomplished successfully.

2013-2014:

Field experiments were conducted during summer/fall 2013 targeting two spotted spider mites in order to evaluate and improve efficacy of biopesticides against twospotted spider mite. The results are presented in Fig. 1a. The bioinsecticides, Recquiem and PFR-97, were ineffective compared with the conventional insecticides such as Omite, Oberon, and Zeal. In fact, the spider mite populations were higher in the plots treated with these bioinsecticides than in the untreated plots. Overall, field mite populations were low to moderate and did not impact mint yields. Evaluation of potential and commercially available predatory mites was conducted in laboratory and greenhouse-based experiments in 2014 field season.

Other field experiments conducted during summer/fall 2013 were based evaluating the efficacy of soil-applied granular Bt against mint root borer (MRB), larval mint flea beetle (MFB) and strawberry root weevil (SRW). During the reporting period, project staff evaluated the degrees of peppermint rhizome damage by these three root-feeding insects. Different biopesticides along with reduced-risk insecticides from various sources were evaluated separately in plot experiments at IREC. Summary results are presented here. Coragen applied during the peak flight of MRB performed the best. Bt product (Bt, 150 lbs/acre) showed a reduced rhizome damage compared with the control treatment (Fig. 1b). We also compared reduced risk insecticides, biopesticides and combinations targeting SRW larvae (Fig. 1c). Because of extremely low infestation by MFB in 2013, project staff did not include MFB data in the analysis. However, the rhizome damage by the other two root-feeding insects (MRB and SRW) was assessed by taking samples from the plots treated with products targeted for MFB (Fig. 1d). Overall, these results showed the prospects of different biopesticides and the reduced-risk insecticides in peppermint insect pest management.

The degree of peppermint rhizome damage by MRB, MFB, and SRW (root-feeding insects) was evaluated. Different biopesticides along with reduced-risk insecticides from various sources were evaluated separately in plot experiments at IREC. Coragen applied during the peak flight of MRB performed the best and this finding was in congruence with previous years' findings. Bt product (150lbs. /ha) showed a reduced rhizome damage compared with the control treatment. Reduced risk insecticides were also compared to biopesticides and combinations targeting SRW larvae. The infestation of MFB in 2013 was extremely low.

For extension and dissemination, the research findings were presented during the annual meeting of the Entomological Society of America in Austin, Texas in November 2013.

2014-2015:
In June 2014, with regeneration of mint in the field, project staff selected and established experimental plots in grower fields in McArthur and Tulelake, and also the fields located at IREC for the year's research activities. Biopesticide and reduced-risk insecticide trials targeting TSM and root feeding insects (MRB, SRW and MFB) of mint were conducted at the IREC. Studies that were focused on assessing the infestation status of commercial mint fields by TSM were conducted in grower fields located in McArthur and Tulelake. These studies partially fulfilled the initiation of demonstration plots in commercial mint fields, but due to time constraints and other activities in the field, this activity was not fully completed. See "Lessons Learned" below for more information. Evaluation and improvement of efficacy of biopesticides/biocontrol agents against TSM by releasing predatory mites was conducted as a cage-based study to evaluate the performance of locally-collected predatory mite species and the commercial predatory mites in reducing TSM population.

Field experiments were conducted during summer and fall 2014 in order to evaluate and improve efficacy of biopesticides against TSM. Treatments (replicated four times) were applied in late July 2014. Based on results, cumulative mite days were the lowest in Oberon 12 fl oz (50.1 days) followed by Oberon 16 fl oz (49.6 days), Onager (55.6 days), and then Zeal (55.9 days). These values were statistically the same. The untreated control had the highest mite infestation (113.3 mite days). The neem-based miticide Trilogy did not perform well and had a mite infestation (112.9 mite days) almost equal to the control. However, microbial insecticide PFR 97 showed better mite control compared with Trilogy and the control. Details are presented in Figure 2 below. In terms of oil yield, the mean oil yield among treatments ranged from 64.8 to 75.8 lb/acre, which can be seen in Figure 3 below.

A predatory mite release study was conducted in one of the commercial mint fields in McArthur, California during late-July 2014. Commercially available predatory mites, *Neoseiulus fallacis* and *Galendromus occidentalis,* as well as field-collected predatory mites were released. Four treatments including the control were replicated four times; a total 16 mite exclusion cages (2 ft. x 2 ft.) were used. Number of TSM, eggs and predatory mites were counted twice a week. Initial counts were performed before each release of the predatory mites. Overall, locally-collected predatory mites performed the best in reducing TSM populations from about a week of the first release, although a confirmatory study is needed to make a definite conclusion.

The other field experiment conducted during summer/fall 2014 was evaluating efficacy of soil-applied Bt against mint root borer (MRB), larval mint flea beetle (MFB) and strawberry root weevil (SRW). Ten treatments including Bt, entomopathogenic fungi, entomopathogenic nematodes and a chemical insecticide (Coragen) were applied twice in a 15 day interval during the peak MRB flight. Five mint rhizomes (~10-15 cm long with at least five nodes) from two locations in each plot were evaluated for percent rhizome damage. Coragen, which is a reduced-risk insecticide, showed the best control of MRB with significantly the lowest percent rhizome internode damage (10%) among treatments. The highest damage (30% damage) was recorded in untreated control which was significantly different from Bt galleriae, Met 52 (entomopathogenic fungus), and entomopathogenic nematode treatments, which can be seen in Figure 4 below.

Overall, these results from field experiments showed a good potential of different biopesticides and reduced-risk pesticides in insect pest management of peppermint in California. UC IPM Guidelines for peppermint were updated and peer-reviewed publications were prepared.

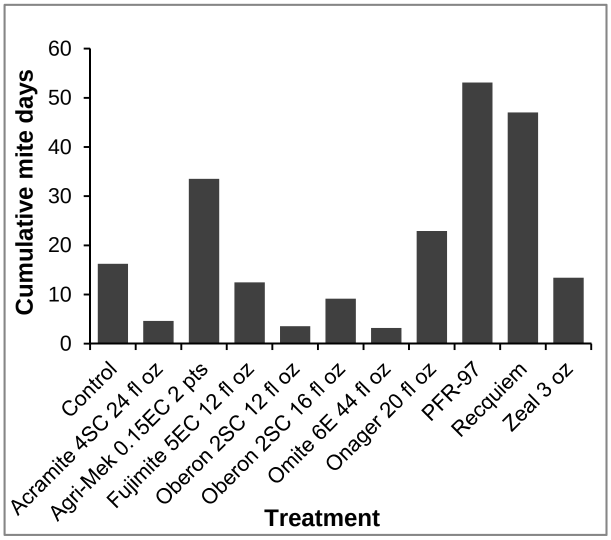


Fig. 1a. Effect of different treatments on seasonal spider mite population-2013

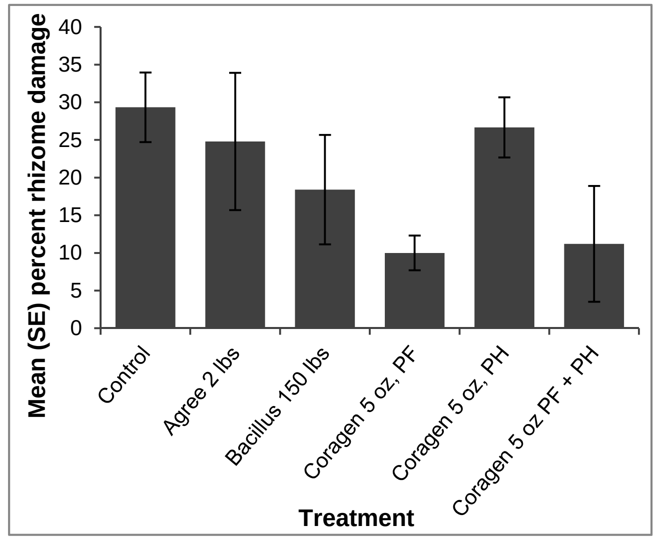


Fig. 1b. Effect of different treatments on rhizome damage by larval mint root borer (MRB)-2013

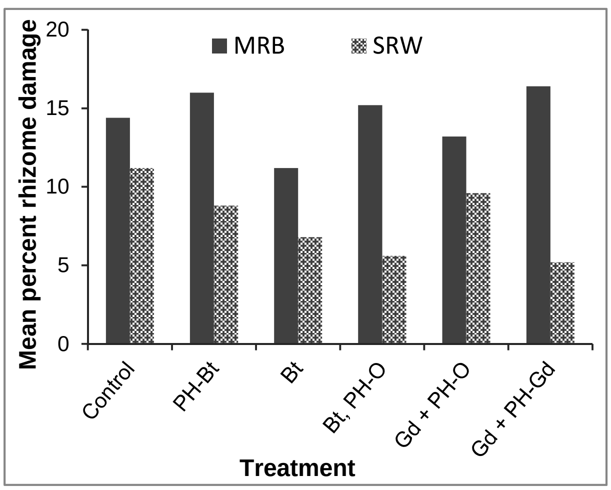


Fig. 1c. Effect of different treatments targeting strawberry root weevil (SRW) larvae on rhizome damage by SRW and MRB-2013

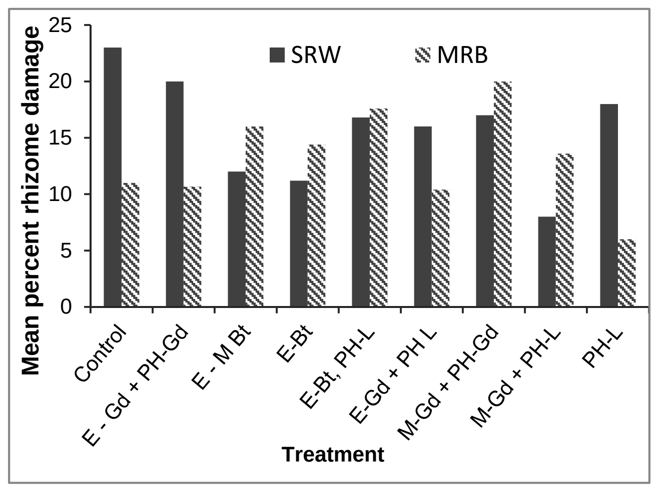


Fig. 1d. Infestation status of SRW and MRB in experimental plots treated with different treatments targeting mint flea beetle-2013

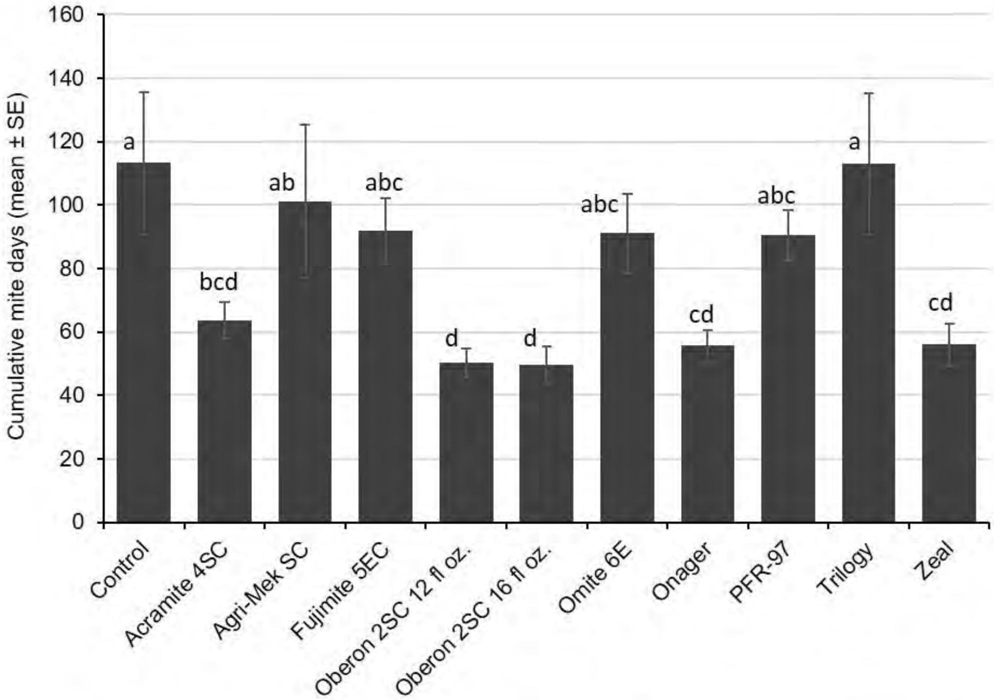


Fig. 2. Effect of different treatments on twospotted spider mite population in peppermint at IREC, Tulelake, 2014. Means followed by the same letters are not significantly different at the 0.05 level of significance.

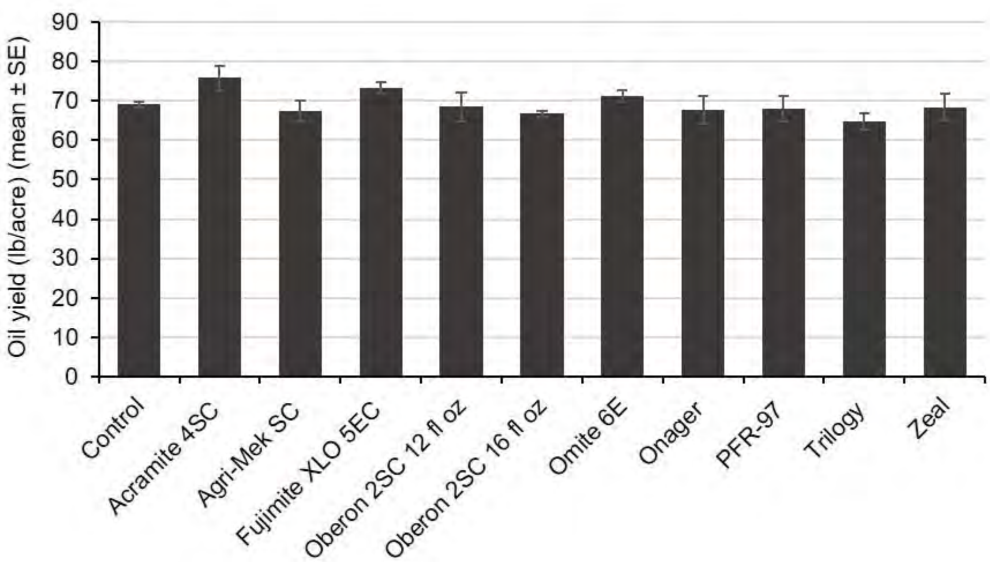


Fig. 3. Effects of different treatments targeting twospotted spider mites on peppermint oil yield-2014, IREC, Tulelake. Means followed by the same letters are not significantly different at the 0.05 level of significance.

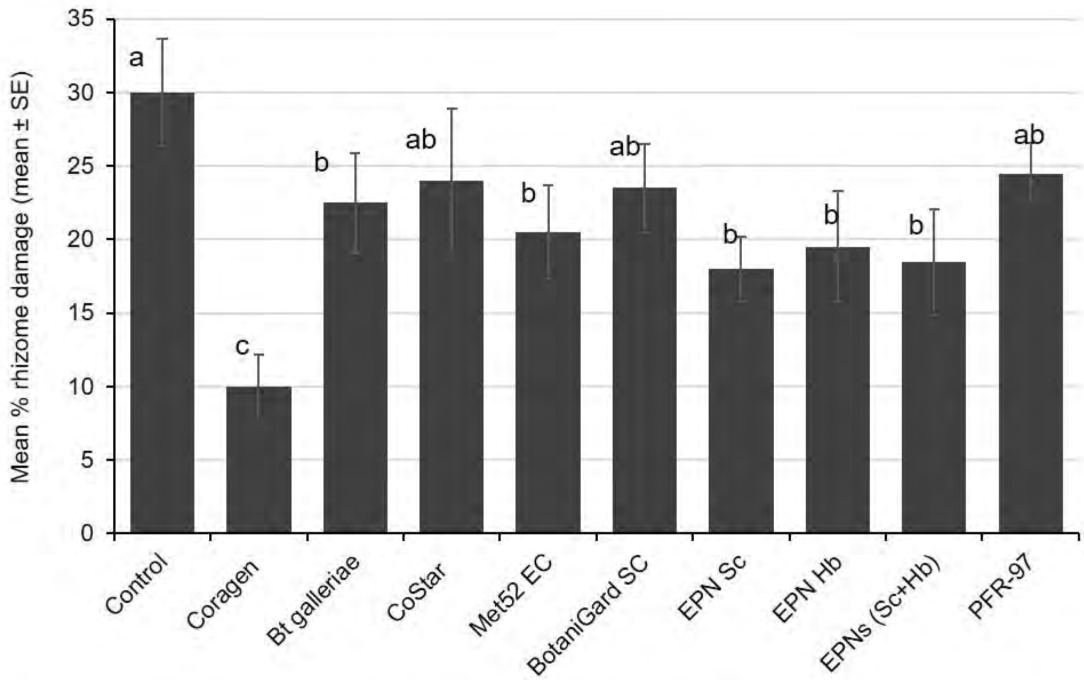


Fig. 4. Effects of different treatments on rhizome damage by larval mint root borer-2014, IREC, Tulelake. Means followed by the same letters are not significantly different at the 0.05 level of significance.

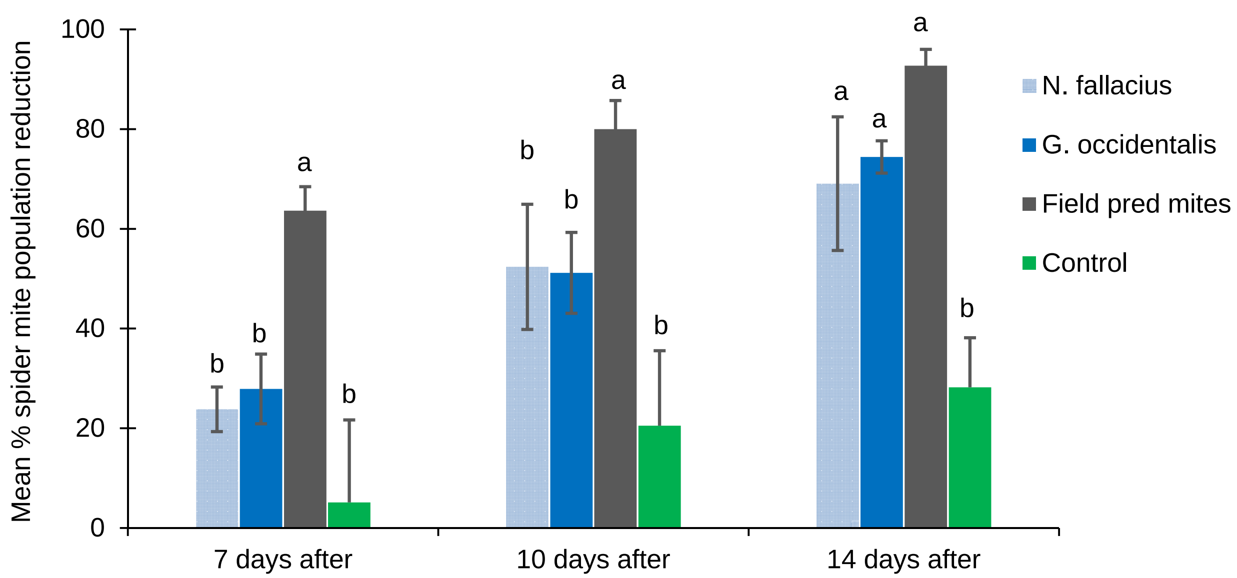


Fig. 5. Percent reduction TSM population after the first release of predatory mites in field cages-2014

All the activities and studies under this project were focused on developing IPM of peppermint which is a California specialty crop.

One of the project collaborators was the Cooperative Extenstion Farm Advisor from the ANR Intermountain Research and Extension Center (REC) in Tulelake, California. The director of the ANR Intermountain REC, provided peppermint growing plots in the research station for experiments. Also, he assisted in finding cooperator growers for field based studies in Tulelake area.

Another project collaborator was the Cooperative Extension Farm Advisor from the Shasta-Lassen Office in McArthur, California. The Cooperative Extension Farm Advisor was instrumental in coordinating growers for different studies in McArthur area.

Goals and Outcomes Achieved

In order to reduce OP usage by 50%, project staff completed the following activities, as described in the Project Approach section above:

- Evaluated and improved efficacy of biopesticides against TSM and releases of predatory mites
- Evaluated and improved efficacy of foliar-applied Bt against MRB larvae using time-specific applications
- Evaluated efficacy of soil-applied granular Bt against MRB, MFB larvae and SRW
- Conducted demonstration studies in commercial peppermint fields (partially completed- see below)
- Participated in Grower outreach, field days, professional meetings
- Updated UC IPM Guideline for peppermint and prepared peer-reviewed publications

Grower outreach, field days, professional meetings, preparation of peer-reviewed publications, and updates of UC IPM Guidelines for peppermint were conducted during the project. These activities will remain active for few more years, and will be accomplished by presenting study results in various technical and professional meetings, involving in outreach activities, continuing to update the UC IPM guidelines for peppermint, and publishing peer-reviewed articles.

Conducting demonstration studies in commercial peppermint fields, which was scheduled to occur in March-June 2015, was only partially fulfilled because of the timeline of the project. The project ended in June 2015, the normal time in which mint plants in the field begin to rejuvenate, and the insect pest activities start even later (after July). Therefore, establishing a demonstration plot in the field as planned could not be fully accomplished. However, project staff have accommodated studies that were focused on assessing the current infestation status of mint fields by TSM in four grower fields located in McArthur and Tulelake. These studies provided the general idea about the degrees of infestation by TSM in commercial peppermint fields in California.

The goal of this project was to reduce the use of organophosphate insecticides (OPs) by 50% with the current use in four peppermint growing fields in Shasta, Lassen, Modoc, and Siskiyou counties. Although project staff don’t have pesticide use pattern data (CA-DPR PUR) for recent years (2013-2014), based on the previous years’ trends (2011-12), it is a valid assumption that the use of OPs has been reduced significantly in peppermint production in California. This statement is based on the response from growers during the field days and other meetings. Although the use of biopesticides is still low, the switchover from high-risk pesticides to relatively safer ones has been increasing. Results from a 2014 biopesticide trial may improve the adoption of these types of products (upon availability to use in mint) in the future.

Another goal of this project was to provide IPM-based management practices to mint growers in California based on the field research results to improve the sustainability of the production system. The development of pest monitoring tools and evaluation of reduced-risk pesticides was completed. To meet this goal, project staff included reduced-risk and several microbial-based insecticides in studies to evaluate performance against the root feeding insect complex, including MRB, MFB, and SRW, and against TSM on mint. For TSM control, in both 2013 and 2014, miticides Oberon, Onager and Zeal performed stronger in reducing total mite days than the other eight treatments including the untreated control. There was no statistical difference on mint oil yield among treatments than control in both 2013 and 2014. The degree of mite infestation (measured as mite days) showed an effect on mint oil quality. Mite days was negatively associated with menthol (desirable component of the mint oil) content, while positively associated with menthofuran (undesirable component of the oil) based on the pooled data from 2013 and 2014 experiments. Focusing on root feeding insects (MRB), Coragen (reduced-risk insecticide, the grower standard) and biopesticides (nematode and Bt-based products) showed promising results in reducing mint rhizome damage by MRB larvae. With further confirmatory studies, project staff may be able to recommend these pest control practices to mint growers, leading to reduced use of chemical pesticides. These findings may be useful for California mint growers in making pest management decisions.

-For TSM control, in both 2013 and 2014, miticides Oberon, Onager and Zeal performed stronger in reducing total mite days compared to other treatments (Fig. 1a; Fig. 2).
-Predatory mite trial showed a good control of TSM using locally-collected predatory mites in cage-based study (Fig. 5). This demonstrates the importance of proper monitoring to determine the threshold population level for control and use of control measures with due consideration of protecting naturally occurring predatory mites in the field.
-Reduced risk insecticide, Coragen, had a good control of MRB damage (Fig. 1b; Fig. 4) and this is crucial in replacing OPs for peppermint production.
-Releases of commercially available predatory mites in controlled studies provided good control of TSM but somewhat less than predatory mites that were collected from mite fields (Fig. 5). This indicates that there is some local adaptation of the predatory mites to mite fields.
-Biopesticides (Bt, nematode-based) showed promising results (Fig. 1b; Fig. 4) and can be incorporated into IPM-based management of root feeding insects with further confirmatory trials and upon registration for use on mint.
-Growers are aware of the negative effects of older chemistry-insecticides and are willing to cooperate to find new alternatives.

Beneficiaries

The direct beneficiaries of this projects are peppermint growers of California, numbering 50-75, particularly in four northeastern counties (Shasta, Modoc, Lassen and Siskiyou). The total mint growing area occupied by mint is ~5,000 acres. The results of the project will be useful to the Northern California Mint Growers Association to suggest best management practices to their members. Indirectly, researchers from universities and other research institutions of California will also benefit from the project.

Since regular pest monitoring is an integral part of IPM, finding more reliable ways to monitor the pest population and to assess the infestation status in the fields will save time and money for growers while reducing the pesticide load to the ecosystem, and subsequently reducing unwanted effects of chemical pesticides to public health and to the environment. These combined activities have long-term economic benefits. Project efforts can assist in reducing the negative impacts of high-risk pesticides in the agro-ecosystem and to the environment.

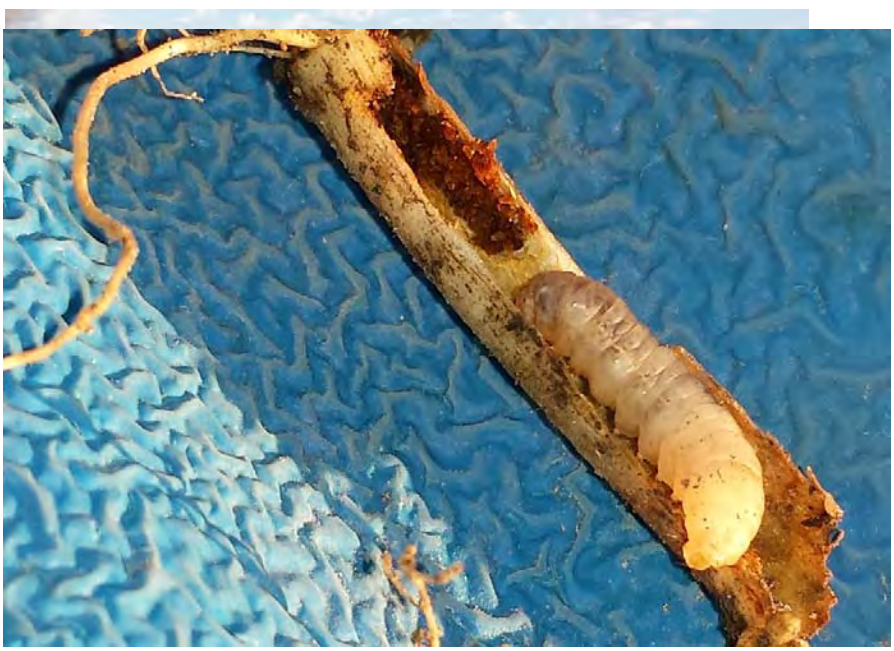
Lessons Learned

Overall, the project activities produced significant positive impact toward reducing high-risk chemical pesticide use and assisting IPM adoption in California peppermint. Some positive aspects of the project were: 1) Emphasis in collaboration: Since this was a collaborative project between UC Davis, UC Cooperative Extension, and mint growers, project staff conducted studies in UC research stations and grower fields. Costs were reduced by growing and maintaining plant stands just for studies. 2) Saving resources: project staff worked closely with biopesticide and other pest control companies and these companies provided testing materials with little or no cost. Project staff hired local technicians in both locations of the project (McArthur and Tulelake) which reduced the cost/time involved in travel. Project staff were unable to fully establish demonstration plots in commercial fields due to limitations of the project duration. Although project staff tried several options to conduct lab-based study of MRB, the task was unable to be completed due to technical difficulty in rearing root feeding insects in the lab.

No unexpected outcomes occurred due to the implementation of this project.

Additional Information

Peer review publication: http://jipm.oxfordjournals.org/content/jipm/4/3/A1.full.pdf
Mint root borer in peppermint: http://www.ipm.ucdavis.edu/PMG/r61300111.html
Two spotted spider mite in peppermint: http://www.ipm.ucdavis.edu/PMG/r61400111.html



Mint root borer larva and damage on mint rhizome

USDA Project No.: 53	**Project Title:** Identification & Development of Olive Knot Resistant Olive Cultivars for Commercial Production in California	
Grant Recipient: United States Department of Agriculture, Agricultural Research Services	**Grant Agreement No.:** SCB12053	**Date Submitted:** December 2015
Recipient Contact: Daniel Kluepfel	**Telephone:** 530-752-1137	**Email:** dakluepfel@ucdavis.edu

Project Summary

Olive knot (OK) disease caused by the bacterium *Pseudomonas savastanoi pv savastanoi* causes significant losses to olive production in California with disease severity being greatest in the northern part of the state where higher rainfall promotes disease development. Economic losses due to OK result in both reduced yield and fruit quality. OK disease is increasingly more important due to increased plantings of susceptible cultivars and introduction of high-density plantings harvested using mechanization. Combined, these activities dramatically enhance disease development. Currently there are two strategies to manage OK, sanitation (i.e. pruning infected material) and application of copper (Cu) bactericides. However continued Cu applications is promoting development of Cu-resistant strains of the pathogen and pruning away and disposing of infected material is time consuming and expensive. Both of these approaches leave the California olive crop vulnerable. The most cost effective disease control strategy for any plant disease is the identification and use of disease resistant host genotypes. Staff exploited the USDA-ARS olive germplasm collection at Wolfskill (Winters, California) to identify OK resistant genotypes which can be used by plant breeders to develop commercially viable OK resistant cultivars. By combining improved disease management strategies with elevated host resistance, the industry will move towards eliminating yield losses due to OK while limiting development of Cu resistance. Staff had a single straight forward objective; Identify Olive genotypes which exhibit resistance/tolerance to OK disease caused by *P. s. pv savastanoi*.

OK disease caused by *Pseudomonas savastanoi pv. savastanoi* is more prevalent in the northern part of the state where higher rainfall promotes disease development. What makes this project timely is the fact OK disease is increasingly more important due to increased plantings of susceptible cultivars and the introduction of high-density olive plantings combined with mechanized cultural practices. All these activities enhance disease spread and development. Currently there are limited disease management strategies for OK disease. This leaves the state’s olive crop vulnerable.

This project was not built upon a previously funded Specialty Crop Block Grant Program project.

Project Approach

The main focus of this study was to identify commercially viable OK resistant olive genotypes. To accomplish this objective staff: 1) Clonally propagated 139 olive accessions maintained in the USDA National Clonal Germplasm Repository (NCGR) at Davis, CA and grew out 15 clones of each accession. 2) In vivo screening. Evaluated clonal trees produced for resistance to the OK pathogen, *Pseudomonas savastanoi pv savastanoi.* 3) Conducted field evaluations of OK disease incidence on mother trees maintained in the collection.

Staff discovered a considerable degree of diversity in the olive germplasm in terms of its tolerance to infection by *Pseudomonas savastanoi* and OK disease development.

1. CLONAL PLANT PROPAGATION.

NCGR generated clonal copies of 139 out of the 157 available genotypes by rooting green cuttings. Rooting success was at or below 10% for approximately 10% of the collection while a rooting success of 90-100% was only observed for about 10% of the collections. The majority of accessions yielded about a 50% rooting efficiency. Additional shoots were collected from poorly rooting genotypes. Fully leafed-out rooted cuttings were transferred over the course of 2 years to the screening greenhouse with average day/night temperatures and relative humidity ranging from 25-27C and 18-20C, and 50 and 80%, respectively.

2. *IN VIVO* GERMPLASM SCREENING.

Plants were screened in 5 separate sets of clones. The average number of clonal plants screened per genotype in a single set was 9 and ranged from 5 to 29. Some genotypes were screened in more than one set resulting in an average of 18 clonal plants screened per genotype. Dole 3 'Oblonga' was included in all sets as a susceptible control and used for data normalization. A total of 2,197 plants were generated and screened from 139 accessions maintained by NCGR. See Table 1 (attached) for numbers of genotypes/plants screened.

Figure 1 (attached) shows screening data to illustrate the diversity of OK resistance. All accessions with a disease resistance rating of 0.75 or below (red line) are exhibiting OK tolerance at what staff believe is a commercially significant level of resistance. Accessions indicated with a black arrow are being further screened to validate original disease resistance screening.

In Figure 2 (attached) staff provide data to describe the relative ability of the accessions to generate OKs at a secondary position in the tree as a result of inoculum introduction at a distant location on the same tree. This also is a useful indicator of a given accession's susceptibility to *P. savastanoi*. The accessions indicated with a black arrow were the same accession which, in Figure 1, also exhibited reduced OK susceptibility at the inoculation site.

In Figure 3 (attached) see the complete project compilation of all disease resistance screening results for the clones generated from the mother trees in the NCGR Olive germplasm collection.

3. ORCHARD OK RATINGS.

OK evaluations/ratings of individual mother trees at the NCGR was conducted annually since 2012. The rating scale was based on the percent of tree branches with OKs present (0 indicates no knots, "1" - 25% branches knotted, "2"-50% branches knotted, "3"-75% branches knotted and "4" indicates 100% knotted). In Fig. 4 (attached) find the complete 2 year compilation of the disease evaluation of the mother trees in the NCGR collection. These data represent the mean of the evaluations performed over a two year period. <u>Note:</u> Accessions identified as being resistant in the primary and secondary knot evaluation as well as in field ratings of the mother tree, will be the focus of additional in depth studies on the genetics of OK resistance.

All of the funds in this project were used to enhance and advance the specialty crop, olives, while developing an understanding of the bacterial OK pathogen *Pseudomonas savastanoi*. This was all done in order to develop long term sustainable options for the control/management of OK disease.

Project oversight was provided by the Project Director and Co-Project Director. The USDA-ARS olive germplasm curators facilitated the rooting of cuttings harvested from mother trees in the germplasm collection. The USDA-ARS laboratory technician managed/propagated the rooted olive cuttings and conducted the pathogen inoculations/evaluations under greenhouse conditions. The PD and Co-PD evaluated the screening/propagation results and assembled the first rough draft of a manuscript which will report the results of this project (see Additional Information section). Recently, the research group also presented results from this project at a regional olive growers meeting in Visalia, California.

Goals and Outcomes Achieved

The activities USDA-ARS completed which enabled project staff to achieve goals and outcomes include;
-Development of disease assessment criteria/rating schemes for disease incidence in the orchard.
-Development of enhanced techniques for rooting cuttings taken from mother trees.
-Proper selection and cultivation of the *P. savastanoi* strains.
-Development of effective and reproducible inoculation procedures.
-Development of disease assessment criteria/rating schemes for disease incidence on greenhouse propagated cuttings.
-Approaches to establish the relative levels of disease resistance exhibited by the different genotypes.

Identify/evaluating most phenotypes for any tree crop is, by definition, a long term goal. In this project, staff made progress towards an understanding of the diversity of OK resistance which exists in the current olive tree germplasm collection. In this effort staff identified a number of olive genotypes which exhibit reduced levels of OK susceptibility, i.e. primary, secondary and orchard level, which can now be exploited by olive tree breeders.

For the most part, the actual accomplishments track fairly closely with the goals initially established in the project. Staff are now staged to initiate limited field trials using the genotypes identified in this project which exhibit elevated levels of OK resistance.

The graph in Figure 3 (attached) presents the "overall" baseline data which illustrates the progress made towards achieving the goal of identifying OK resistant/tolerant olive genotypes. The disease rating for each genotype indicated across the x-axis is shown below. All genotypes with a rating of less than 0.6 are candidates for inclusion in an OK resistance breeding program. All genotypes with a blue bar below the red line (0.6) are genotypes which exhibit reduced OK susceptibility.

Of the 157 Olive genotypes screened, staff identified two genotypes which exhibit less than 50% of the OK incidence exhibited by the benchmark cultivar Dole 3. These genotypes also exhibit limited secondary OK formation. These data suggest that the genes which mediate this tolerance may facilitate dramatic reductions in the amount of Copper-based pesticides applied in the field.

Beneficiaries

Identification of olive genotypes which exhibit elevated levels of resistance to OK disease will benefit both the nursery and olive production industry. Olive breeders will now be able to introgress genetic loci, which mediate disease resistance, into commercially acceptable olive cv's. In addition, the approaches used to evaluate disease resistance in this project will be of benefit to other researchers attempting to design similar screening methodology for tree crops.

In 2012 over 500 growers in California produced approximately 180,000 tons of olives on about 44,000 acres. During 2012, the United States exported 6,989 metric tons (MT) of olive oil, a 66 percent increase from 2011, valued at more than $17.2 million, up 41 percent from 2011. The United States also exported 4,648 MT of prepared olives valued at nearly $9.4 million in 2012. Prepared olives were shipped mostly to Canada and Japan. Finally, the United States shipped 340 MT of fresh olives valued at $843,000 mainly to Canada. (FAS 2012). Each of these growers, handlers, and nursery operators will benefit from the development of OK resistant/tolerant olive cultivars. In addition, the use of OK resistant genotypes will diminish the necessity and frequency of wide spread use of copper-based bactericides which will yield tremendous environmental and societal benefits.

Lessons Learned

Early in the project staff needed to develop a more rapid OK evaluation system for use on the greenhouse propagated plantlets. Initially staff attempted a volume measurement of all OKs to quantify the degree of susceptibility. This was taking an unreasonably long period of time, (i.e. 8-10 min/plant) given the fact staff need to assess disease incidence on hundreds of plants. The USDA-ARS laboratory technician came up with a different approach which was evaluated and statistically proven to provide accurate reproducible results in one tenth the time per plant. The lesson here for all PI's is provide the environment which allows all good ideas, independent of their source, to rise to the top and be accepted in the program.

As mentioned above, USDA-ARS achieved the majority of the goals initially established. However, project staff would encourage everyone working with trees, or other slow growing woody perennials, to temper the goals/outcomes listed as achievable during a relatively short time frame which is typical of most funded grants. Even minor propagation problems with trees, i.e. power failures in the greenhouse, a single missed watering schedule, etc. can dramatically affect the project and result in significant delays which are difficult to recover from in a timely fashion.

Additional Information

USDA-ARS is currently drafting the manuscript in which all the results of this project will be reported. The manuscript will be submitted to the American Phytopathological Society's journal called, "Plant Disease" http://apsjournals.apsnet.org/loi/pdis. In addition staff presented the data at a regional olive growers meeting in Visalia, California. Approximately 75 people (growers, nursery, farm advisors, etc.) attended the meeting.

USDA Project No.: 54	**Project Title:** Developing a management plan for the Asian citrus psyllid in retail nurseries	
Grant Recipient: Regents of the University of California, Riverside, Department of Entomology	**Grant Agreement No.:** SCB12054	**Date Submitted:** December 2015
Recipient Contact: Matt Daugherty	**Telephone:** 951-827-2246	**Email:** matt.daugherty@ucr.edu

Project Summary

The Asian citrus psyllid (ACP; *Diaphorina citri*) is among the most significant threats to citrus production worldwide owing to its role as a vector of the bacterium associated with huanglongbing disease (HLB). All areas where both the insect and disease have become widespread, including Brazil and Florida, have incurred significant losses and increased management costs. In Florida, both the psyllid and disease, spread rapidly in large part due to the unregulated movement of infested nursery plant material. To ensure that a similar outcome did not unfold in California, regulations were put in place that restrict movement of nursery plant material and require specific insectide treatments of all containerized ACP host plants. The current project evaluated ACP management in retail nurseries through monitoring, evaluation of chemical control effectiveness, characterization of the effects of nursery practices on psyllid management, and extension education to nursery employees.

ACP was first found in California in 2008 on residential citrus in San Diego County. Over the next few years it spread throughout residential areas of Southern California. The disease was first documented in 2012, on residential citrus in Los Angeles County. Such infestations and disease cases threaten residential citrus as well as nearby commercial citrus in Southern California. Quarantines were put in place to limit the potential for human-assisted spread of the insect and disease into regions such as the Central Valley. An important part of those quarantines are restrictions and mandated treatments of nursery ACP host plants, to limit their role in long-distance spread as occurred in Florida. However, significant knowledge gaps exist with respect to how well protected nursery plants are and how might ACP management in retail nursery and garden center settings be improved. The current project sought to remedy those gaps and facilitate knowledge transfer to nursery employees on best management practices for this important invasive vector and pathogen.

This project did not build on a previously funded Specialty Crop Block Grant project.

Project Approach

The main goal of this project was to understand the extent of ACP activity in retail nurseries and garden centers in California to inform ways of reducing the risk that nursery stock might play in the inadvertent movement of ACP and HLB. This goal was addressed via four related objectives:

Objective 1: Monitoring of ACP, insecticide residues and residence times of nursery stock at retail locations. The objective included two sets of activities. First, the California Department of Food and Agriculture (CDFA) nursery monitoring database was reviewed of more than 400 nursery finds in the first few years of ACP's invasion in California. Results from that analysis show that some infested nursery shipments had been treated up to three years prior and that at least some plants treated within 90 days were also infested. Secondly, project staff surveyed twenty-nine nurseries and garden centers throughout Riverside, San

Bernardino, and San Diego counties. Although only a handful of shipments were found to be infested, 55% had been treated at least 90 days prior, and 35% had been treated more than one year prior. Of the more than two thousand leaf samples tested from these plants, 90% had concentrations below what is known to induce high mortality in ACP nymphs (i.e. 220 ppb).

Objective 2 and 3: Field trials of insecticide residual effectiveness and ACP establishment over a range of conditions. The first field trial (Objective 2) measured imidacloprid concentration and ACP establishment over time for different combinations of citrus variety (lemon, navel), watering level (120%, 250% or 500% of the background summer evapotranspiration rate), and soil type (more/less sandy) - all of which affected insecticide retention. By twelve weeks, approximately half of the trees were at ACP-ineffective concentrations, and by sixteen weeks, none of the trees had biologically significant imidacloprid concentrations. The second trial (Objective 3) compared imidacloprid with two other systemic insecticides – Dinotefuran and Thiamethoxam. Based on field surveys and bioassays with ACP adults, Dinotefuran proved the most short lived (i.e. 60% had immature ACP present by four months post treatment), imidacloprid was intermediate (30% with immatures four months post treatment), and thiamethoxam was the most long lived (more than 20% with immatures 4 months post treatment).

Objective 4: Extension education for ACP and HLB management in retail nurseries and garden centers. This final objective included presentations to nursery groups and Master gardeners, more than a dozen presentations with over 2,000 attendees total), an online training course for nursery employees, five articles and interviews in trade publications and newsletters, a new UC IPM quick tip focused on ACP and HLB, and blogging.

The project only entailed work related to citrus, a California specialty crop. All effort by project personnel relates solely to this specialty crop.

Project partners included University of California (UC) researchers, extension personnel, and CDFA staff. CDFA staff provided data on nursery finds that allowed for analysis of residence time and estimation of the scale of ACP-impacts in retail nurseries and garden centers. The UC researchers helped to establish insecticide field trials to evaluate the likely effects of nursery practices on systemic insecticide residual effectiveness. The extension personnel contributed to the development of outreach materials (online and print) and helped organize meetings with Master Gardeners and nurseries.

Goals and Outcomes Achieved

The results from Objective 1 suggested that it is common for ACP host plants to reside at nurseries well beyond the regulatory limit of ninety days post insecticide treatment. The results from Objectives 2 and 3 suggest that within four months the majority of treated nursery stock is susceptible to ACP infestation. Objective 4 led to the development of extension materials that relayed that information to stakeholders, including relevant information for improving ACP management in a nursery setting.

The most long-term outcome concerned the field trials, which measured insecticide residues and ACP establishment rates over a more than four month period after insecticide application. Those data are complete and convincingly show that residues drop off and ACP likelihood of establishment on containerized nursery citrus increase substantially by three months post treatment – less for certain insecticides or untreated plants.

Residence time and insecticide residue data from the surveys provided a baseline with respect to room for improvement targets on the part of nurseries. One of the conclusions, and therefore a focus of extension activities, is the need for ways to ensure turnover. The field trials estimated more precisely than before the duration of those residual effectiveness periods of systemic insecticides and offered a comparative assessment of different insecticides – including some (i.e. Thiamethoxam) which outperformed currently recommended products.

One of the main results of the monitoring work is that it is clear that residence times of ACP host plants at retail sites are too long, stores need to work to shorten them to a window more in line with the effective period of the insecticide treatments. Results from the field trials have informed recommendations made by the California ACP Science Advisory Panel to federal regulators to guide requirements in a manner that maximizes the utility of systemic insecticides while also providing some flexibility to nurseries. Finally, the project developed an array of training materials to retail nursery and garden center employees on best management practices that should help with ACP management in their stores.

Beneficiaries

By potentially improving management of ACP in a retail nursery and garden center setting, the project's activities will help to ensure that nurseries do not contribute to continued psyllid spread into new areas and spillover into nearby commercial citrus or residential citrus. Thus, this work will benefit citrus production in a range of settings, including commercial orchards, production nurseries, retail nurseries and garden centers, and residential environments.

It is difficult to estimate a precise number of beneficiaries, but there are well over 500 retail nurseries and garden centers just in Southern California, it is estimated that the majority of residences in the southern part of the state have some citrus in their yards, and it is plausible that reducing human-assisted spread of the psyllid may benefit the over 250,000 acres devoted to commercial citrus production in Southern California and especially the Central Valley.

Lessons Learned

Collectively, the monitoring and field trial data generated during the project provided a clear picture of the length of residual effectiveness of mandated insecticide treatments with the upper limit being arguably less than twelve weeks for the best performing insecticides before treated containerized citrus are at high risk to ACP establishment. Yet, based on the monitoring in nurseries it is clear that the residence times of much of the citrus nursery stock is well beyond that at many retail sites. Thus, one of the main conclusions to be drawn from this project is the need for best management practices that focus on reducing residence times via a tagging and inspection system to keep more precise track of how long ACP host plants have been at a store and adjusting marketing practices to favor the sale of those plants that have resided the longest.

One of the main challenges with this project was organizing extension materials targeting the retail nurseries and garden center employees. As a whole, they are a very diverse group with an organization structure that is different from other stakeholder groups. The project staff attempted to deal with this by developing an array of different, complementary extension resources. It is recommended to engage with stakeholder groups at the outset of new projects rather than waiting until after data collection has begun or management recommendations have been formalized. Such an accelerated timeline for extension activities should provide additional time to develop the necessary relationships with stakeholder groups by the time information becomes available.

Additional Information

Extension materials produced by this project include: An online training course for retail nursery and garden center employees (http://class.ucanr.edu/course/view.php?id=26), the Residential and Nursery Asian Citrus Psyllid Blog (http://cisr.ucr.edu/urbanACP/), a new ACP and HLB Quick Tip for Nurseries (http://www.ipm.ucdavis.edu/RETAIL/QT/asiancitruscardrn.html), articles in UC Nursery and Floriculture Alliance News (http://ucanr.edu/sites/UCNFAnews/), and articles in Retail Nursery and Garden Center IPM News (http://www.ipm.ucdavis.edu/RETAIL/retail-newsletter.html).

USDA Project No.: 55	**Project Title:** Assessing Increased Efficacy of Rodenticide Baits Containing Metabolic Inhibitors	
Grant Recipient: United States Department of Agriculture, National Wildlife Research Center	**Grant Agreement No.:** SCB12055	**Date Submitted:** December 2015
Recipient Contact: Katherine Horak	**Telephone:** 970-266-6168	**Email:** Katherine.e.horak@aphis.usda.gov

Project Summary

This project developed a rodenticide bait with increased efficacy in voles, specifically vole populations resistant to current anticoagulant baits. Prolonged use of anticoagulant rodenticides to control voles has led to the development of animal populations that are resistant to these toxicants. This means that although agricultural producers continue to follow previously successful rodent control strategies, they no longer control rodent populations. This decrease in rodenticide efficacy causes increases of crop damage to levels that are unsustainable for the business posing a serious threat to the artichoke industry. Without novel toxicant development, resistant voles will force serious changes to the agricultural practices in California's central valley, perhaps driving some producers out of business. By developing a rodenticide effective against resistant vole populations this project will directly benefit the artichoke producers.

This project generated efficacy data, both laboratory and field, for a novel rodenticide formulation containing additives being designed for the control of anticoagulant resistant rodents. The use of anticoagulant rodenticides to control voles in artichoke fields has been on-going for decades. Because of this continued use, populations of rodents are now resistant to anticoagulants. These populations pose a serious threat to the artichoke industry in California's central valley, which produces almost 100% of the commercially grown artichokes in the United States. The peak crop value of these artichokes was during the 2007-2008 growing season at $50 million (CA Artichoke Advisory Board, 2012). The financial burden of controlling resistant populations of voles dramatically increases costs of artichoke production. It has become necessary for growers to deploy teams of workers to walk the fields and dig up burrows to get rid of the rodents. These pest control practices are not sustainable. The benefits of the novel bait formulation resulting from this project will safe guard the approximately 7,500 acres of artichokes in California, ultimately decreasing man hours spent on rodent control and increasing crop yield per acre.

For many decades the main method of rodent control was chlorophacinone treated artichoke bracts. Due to this continued use, agricultural producers are now faced with trying to control voles that are resistant to the anticoagulant rodenticides. This project will give artichoke producers a novel rodenticide effective against resistant voles that can be used to protect the artichoke crops in a cost effective manner. Artichoke producers have to use a significant amount of money in baits and man power attempting to save their artichokes to take them to market because current control measures are not working to protect crops. If an effective way of controlling voles was not found, the financial burden would force California artichoke producers to raise the price of their produce. This will make their produce less competitive and could result in less consumers willing to purchase artichokes.

This project does not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Objective 1: Artichoke Grower Survey

The goal of this objective was to determine site for field testing. As discussed in the "Lessons Learned" section, it was challenging to survey artichoke producers directly. Therefore, a single producer was used as a liaison between producers and scientists. This was highly effective because the liaison was on site with the producers and could discuss questions in person.

Objective 2: Determine palatability of bait additives to captive voles

Methods:

The taste preference of voles for food pellets made with varying concentrations of the two additives was determined using two choice tests. *In-vitro* screening has shown that both additives significantly inhibit metabolism at a concentration of 5% of the incubation solution. Therefore, testing of the palatability of these additives was clustered around a concentration of 5%, specifically in the range of 1-20% of either additive of interest. Food pellets were made using powdered rodent chow, specifically LabDiet 5001 rodent diet (protein ≥23%, crude fat≥4.5%, fiber ≤6%, ash≤8%, minerals≤2.5%). Food pellets were made by mixing the powered grain bait with water until a dough-like consistency was achieved, approximately 850 mL water for 1000g powered grain. The powered rodent chow was mixed with either a powered or liquid form of additive of interest at the desired percent concentration dry weight. This dough-like mixture was then formed into pellets, allowed to dry, and offered to the voles in preference testing. The control 0% additive of interest food pellets was made without adding either of the compounds of interest.

Preference Testing:

The taste preference of voles was tested by comparing consumption of feed pellets with two different concentrations of additive of interest. In every preference trial the consumption of a varying concentration of additive of interest was compared to the consumption of food pellets with 0.5% additive of interest to account for any neophobia. A basal food pellet consumption rate was determined by offering voles only food pellets without either additive of interest.

During the 48 hour two-choice tests, subjects were provided 20 grams of both the 0.5% compound pellet and the comparison pellet. The position of the 0.5% (left or right) was stratified among subjects and alternated daily for each subject. Diets were replaced daily and intake determined by difference (initial mass - mass after 24 hours). Subjects had *ad libitum* access to water during preference tests. Six voles were used to test each concentration of the additive of interest. Three concentration levels of each additive of interest were tested.

Statistical Analyses:

Intake data from two-choice tests, preference scores (intake of one diet divided by the sum of both diets) was analyzed by using analysis of variance with treatment and day fixed effects and subject a random effect. The null hypothesis of indifference was tested by using the value 0.5 minus the preference score as the response in the model.

Results and Discussion:

Daily food intake data show that many voles had a significant side preference for the food block. This side preference seemed to drive their food choices more than the additive in the food block; that is, when the two day consumption data are averaged there is no preference difference between the blocks. There were no differences in the preference scores between male and female voles. Therefore, the data are combined for final analysis.

	Preference Score
Additive 1	
2.5%	0.59
5%	0.53
25%	0.52
Additive 2	
2%	0.48
5%	0.49
10%	0.49

Table 1: Preference scores from two day consumption tests with food block formulated with either additive 1 or 2.

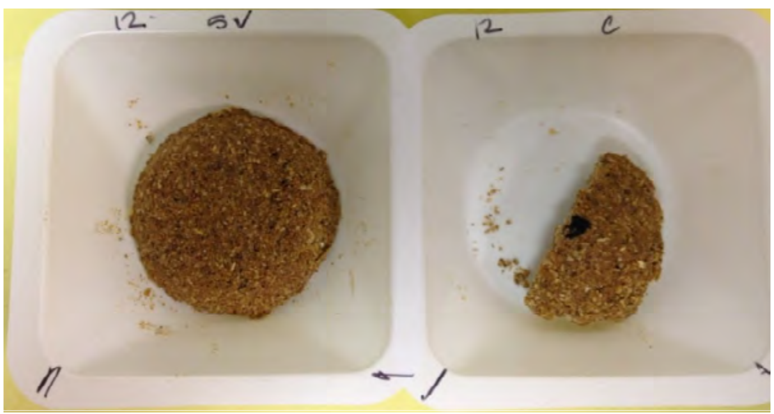


Figure 1: Food pellets after being offered to vole for 24 hours. This vole consumed more of the bait on the right than the left in that 24 hour period.

Objective 3: Determine efficacy of rodenticide/additive formulations. This study was performed exactly as planned.
Methods:
The next step in the development of a more efficacious chlorophacinone bait is whole animal testing of the chlorophacinone with the food additives. Food pellets were made by mixing the powered grain bait with water until a dough-like consistency was achieved, approximately 850 mL water for 1000g powered grain. The powered rodent chow was mixed with either a powdered or liquid form of compound of interest at the desired percent concentration dry weight. This dough-like mixture was then formed into pellets, allowed to dry, and offered to the voles in preference testing. Chlorophacinone concentrations in baits was determined using High-Performance Liquid Chromatography (HPLC).

Prior to being placed on test, the normal rodent chow was replaced with control pellets for up to 5 days to reduce neophobia during the trial. For these tests, 10 animals were offered bait pellets formulated with chlorophacinone and either 10% or 25% food additive in a no-choice trial for up to seven days. Daily bait consumption was determined by weighing remaining food pellets every morning. After seven days normal food pellets was offered. Animals that did not succumb to the anticoagulant during the seven day feeding period were monitored for four additional days or until they appeared in normal health (grooming normally, eating, normal activity levels).

Statistical Analyses:
Voles were randomly selected for treatment group. For each bait formulation an LD_{50} (lethal dose - the amount of an ingested substance that kills 50 percent of a test sample) was calculated. The efficacy of rodenticide formulations was compared using the LD_{50} values.

Results and Discussion:
The baits formulated with additive at both 10 and 25% had increased efficacy compared to chlorophacinone alone. The additive did not induce bait shyness as shown by the bait consumption data. There was not a significant difference in the time to death between any of the groups. These data supported moving this additive formulation to field trials to see if it would have increased efficacy when compared to chlorophacinone alone while there were other food choices available

	Efficacy (dead: total #)	Time to Death Ave days	Normalized bait consumption (g bait/ days alive)
Chlorophacinone	3:10	8.7	2.7
Chl + 10% additive X	5:10	7.8	3.1
Chl + 25% additive X	6:10	9.3	2.2

Table 2: Data from caged vole trial investigating the efficacy of chlorophacinone baits formulated with 10 or 25% of additive X

Objective 4: Determine field efficacy of rodenticide/additive formulations.
The first round of field trials were done in December 2013 during the historic rain and flooding in Castroville, CA. Because of the rain, the field site was completely flooded after voles had been caught and radio-collared and bait had been applied. All of the voles that were in the study died due to the flooding. Therefore, there is only data from one field trial. This resulted in the number of animals per study group being half of what was planned. There will need to be additional field studies performed to provide sufficient data if a novel formulation registration will be pursued.

Methods:

- Voles captured and radio-collars placed on each animal.
- Ten voles placed in each 1/16 enclosure
- Either 0.1% chlorophacinone + 25% additive placed inside enclosures
- Voles monitored daily for 13 days, time based on time to death of cage trials
- Voles that succumb to effects of bait were recovered, frozen for further residue analysis

- Any voles alive at the end of the study were captured, euthanized, frozen for further analysis

This study was planned to be done two separate times to achieve the numbers of voles in each treatment group to yield significant results. However, due to inclement weather and flooding, the first round of testing could not be completed and therefore there is no data from that round. Each replicate used 30 voles (10 chl control, 20 chl + additive).

Statistical Analyses:
Efficacy was determined by dividing the number of voles that died by the number of voles that did not succumb to the treatment and had to be euthanized. Project staff attempted to use food block chew data as another measure of efficacy. However, due to challenges discussed in the "Lessons Learned" section the chew blocks were not an accurate measure of efficacy or vole density. Staff assumed a P value of < 0.05 to represent a significant difference

Results and Discussion:
The chlorophacinone + additive plots did have high efficacy with 9 out of 10 and 8 out of 10 voles succumbing to the bait. The radio-collars fell off of many of the animals in the chlorophacinone only plot (6 out of 10 voles). This complicates the efficacy data since scientists were not able to track the voles without the collars and therefore could not determine their location. However, most of the voles that succumbed to the treatment were found dead above ground (18 out of 21 total). Only four voles were found dead in the chlorophacinone only plot. When considered in light of the fact that most of the other dead voles were found above ground, this indicates that the chlorophacinone + additive treatment was more efficacious than chlorophacinone only. However because of the flooding the study had half as many animals as predicted and therefore does not have the statistical power to make any statements about increased efficacy.

Figure 2: Artichoke bracts being applied to the field trial plots.

	Efficacy (dead: total #)	Time to death ave days	Found above ground (total #)
Chlorophacinone	4:10*	5.2	4
Chl + additive Plot 1	9:10	6.5	6
Chl + additive Plot 2	8:10*	3.8	8

Table 3: Data from field vole trial investigating the efficacy of chlorophacinone baits formulated with 10 or 25% of additive X.
*: In chlorophacinone group six animals lost collar, not found above ground, and therefore assumed to have survived. In chlorophacinone + additive group one animal lost collar, not found above ground, and therefore assumed to have survived.

Objective 5: Residue analysis in vole tissue. This was completed as planned. Liver residue levels were determined using HPLC for all carcasses from the field studies.

	Average chlorophacinone concentration (ppm + SEM)
Chlorophacinone	6.46 ± 3.11
Chl + additive Plot 1	11.85 ± 2.51
Chl + additive Plot 2	15.31 ± 4.30

Objective 6: Project completion. Peer reviewed manuscripts are in preparation awaiting data from future field trials.

The scope of this project only benefited specialty crops. All work was done on voles from the artichoke farms in California and in the fields of the specific specialty crops to ensure that the exact needs of specialty crop producers in California were addressed.

Project partners included agricultural producers that assisted with capturing voles and making field plots.

Goals and Outcomes Achieved

This project consisted of two caged-animal trials and two field studies that, together, were used to develop a novel rodenticide bait.

Baseline data was vole density in fields. As explained above, the indexing methods that were planned were not effective in the field locations. Therefore, staff used reports from agricultural producers as baseline data for number of voles in fields prior to testing. The baits with additives were more efficacious than the current baits as illustrated by cage and field efficacy trials.

The major successful outcome of this project was the development of a palatable rodenticide bait with increased efficacy against resistant voles found in specialty crops (artichokes) in California. Data from caged trials showed an increase in efficacy.

	Efficacy	Time to Death	Normalized bait consumption
	(dead: total #)	Ave days	(g bait/ days alive)
Chlorophacinone	3:10	8.7	2.7
Chl + 10% additive X	5:10	7.8	3.1
Chl + 25% additive X	6:10	9.3	2.2

Also, data from field efficacy are promising but due to extensive flooding and collars falling off voles additional field trials will have to be done to increase the number of animals involved in field studies whereby providing data for registration of a new rodenticide formulation.

	Efficacy	Time to death	Found above ground
	(dead: total #)	ave days	(total #)
Chlorophacinone	4:10*	5.2	4
Chl + additive Plot 1	9:10	6.5	6
Chl + additive Plot 2	8:10*	3.8	8

Beneficiaries

Artichoke growers throughout California will benefit from the results of this research project. Artichokes are grown on approximately 7,500 acres in California's central valley. These producers use the same rodent control strategies because of their geographic similarity. As a result, approximately 100% of the producers are negatively impacted by resistant voles. This amounts to 40-50 both large and small scale artichoke farm producers. Through personal communication, one agricultural producer reported that his large scale farm was losing up to 80% of the artichoke crop to damage from resistant voles last growing season. By developing and field testing novel rodenticide formulations this project positively, directly impacted all of the artichoke producers in California's central valley. Since the conclusion of the study, scientists are making progress informing producers of the experimental findings, both novel bait formulations and efficacy data. By informing the producers an integrated pest management plan based on the most current information can be made by each farm.

This project will benefit all of the artichoke producers in California's central valley (40-50 large and small scale artichoke farms). Since the problem of anticoagulant resistance is widespread all producers affected by it will have economic benefit by reduced cost of pest management.

Lessons Learned

One of the lessons learned is how challenging it is to get an index of density of voles in the plots prior to starting each trial. In discussions with the artichoke producer while planning the studies it seemed that using chew blocks and trap nights would be a good measure of vole density in the fields of interest. This turned out to not be the case. The voles were not moving around much and therefore were not getting in the traps. To capture the voles used in the enclosures for the trials, the field crews at the farm hand captured the voles by digging up burrows. Chew blocks were placed in all of the enclosures before the study began to assess rodent density. When researchers came back the next day 75-90% of all of the blocks had been consumed. Discussions with the producer made it clear that vole were not chewing the blocks; it was field mice which do not cause damage to the artichoke plants. Because basically the entire chew block was consumed by the mice, it no longer served as an accurate estimate of vole density. The lesson learned through this project is that determining accurate estimates of the vole populations is very challenging.

Figure 3. Chew blocks used to determine vole density. Photos show level of consumption after one night in the field. This consumption was done by field mice; therefore chew block were not an accurate way of determining vole density.

An unexpected result was that the average time to death of the chlorophacinone alone versus the chlorophacinone with additive was not different in field studies. Based on caged studies, it was expected that the animals in the chlorophacinone with additive group would succumb more quickly than chlorophacinone alone. Further studies are needed to determine if the decrease in time to death suggested in the caged trials will also happen in the field. This would be a benefit to the new formulation with the additive as animals that had consumed bait would be alive on the landscape for less time and therefore, less likely to be caught by a non-target animal.

It was challenging to survey all artichoke farmers. Therefore, a single artichoke producer was used as a point of contact for the famers. This contact asked other producers damage levels, baiting strategies, and opinions on the efficacy of current baits. This turned out to be the best and most accurate way of acquiring data from the producers as a whole as the point of contact was more aware of the landscape and, because he was at the farms, could contact other producers easily.

Additional Information

All of NWRC publications are posted here: http://digitalcommons.unl.edu/icwdm_usdanwrc/

California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.: 56	**Project Title:** Detection and quantification of pathogenic Pythium species in Calla lily soils	
Grant Recipient: United States Department of Agriculture, Agricultural Research Service	**Grant Agreement No.:** SCB12056	**Date Submitted:** December 2015
Recipient Contact: James Gerik	**Telephone:** (559)596-2865	**Email:** James.gerik@ars.usda.gov

Project Summary

There were 2 main purposes of this project.

1) To determine the etiology of the root rot disease of calla lily.
2) To develop a quantitative assay for the pathogenic agent.

Cut flowers, bulb and ornamental crops are highly productive and valued component of California's agriculture. In 2010, California growers produced cut flower crops with a wholesale value of $286 million. The wholesale value of this crop has been decreased dramatically mainly due to the susceptibility of calla lily to soilborne pathogens, particularly a species of Pythium, that limit its production and lower the quality of rhizome.

The identification and control of this disease is of the upmost importance to the calla lily growers. The ability to quantify the population of the pathogen in the soil will allow for the growers to make decisions on land rental and soil fumigation.

This project does not build upon a previous Specialty Crop Block Grant Program funded project.

Project Approach

Activities performed include:

1. Collected total 63 calla lily root rot samples from more than six field sets.
2. Isolation and identification of *Pythium* species using Polymerase Chain Reaction-Restriction Fragment Length Polymorphism (PCR-RFLP) (cox2) and sequencing (cox2, and ITS or cox1) based assay, several species (*P. araceacium, P. spinosum, P. ultimum and P. irregular)* were identified. Morphological features of *Pythium* species were observed; particularly, morphology of new species *P. araceacium* was described in detail.
3. Pathogenicity test with mycelia plugs were conducted to infect calla lily root sections in greenhouse. Total Sixty-three samples were tested. Fifty-nine samples were pathogenic. Among them, fifty-three samples are *P. araceacium*; five samples are *P. spinosum*; one sample is *P. ultimum*. Three of four non-pathogenic isolates are *P. irregulare*.
4. Design pathogenic-specific primers and probe. Alignment of cox2 genes of *Pythium* species, primers and probe were designed which can specifically recognize pathogenic isolates, but not non-pathogenic isolates.
5. DNA extraction. DNA extraction form mycelial mats of *Pythium* species using the DNAeasy Plant Mini Kit (Qiagen) and DNA extraction form soils using Power Soil® DNA Isolation Kit (MO BIO Laboratories, Inc. Carlsbad, CA) were conducted. Those methods are effective to remove PCR inhibitors.

6. Test Real-Time PCR specificity. Both pathogenic and non-pathogenic isolates of *Pythium* and other soil fungal pathogens in California were used to test TaqMan PCR specificity. The results showed the method only can detect and quantify pathogenic isolates, not the other pathogens.
7. Develop standard curves for pathogenic *Pythium* species. A serous of DNA concentration of *P. araceacium* and *P. spinosum* were used and TaqMan real-time PCR were conducted. Standard curves were generated.
8. Detect and quantify pathogenic *Pythium* isolates. Soil samples were collected from calla lily fields and soil DNA were extracted. The TaqMan real-time PCR was conducted for detection and quantification of pathogenic isolates in soils.
9. Soil plating assay. To test the sensitivity of real-time PCR, soil plating experiment was conducted. Real-time PCR appears more fast, sensitive and precise method to detect pathogenic *Pythium* species in soils.

The main project beneficiary was the calla lily. Staff identified *Pythium* species and developed real-time PCR to detect and quantify pathogenic species in soils, which is of the upmost importance to the calla lily growers to make decisions on land rental and soil fumigation. In addition, this method also can use to detect other soil pathogens in other perennial specialty crops in California.

Contributions from project partners include:
1. Identified *Pythium* species in calla lily fields; particularly those species are also the major species in soils in Santa Cruz and Monterey countries. Those were performed by ARS and UC Davis (UCD) researchers.
2. A new *Pythium* species, *P. araceacium,* was identified as the major pathogenic species of calla lily. This was performed by ARS and UCD researchers.
3. Developed a highly specific real-time PCR assays which can specifically detect and quantify pathogenic *Pythium* species in soils. This was conducted by a UCD researcher.

Goals and Outcomes Achieved

1. Identified the major pathogenic species causing calla lily root rot in more than six fields, named *Pythium araceacium.*
2. Developed real-time PCR to detect and quantify pathogenic *Pythium* species in soils and presented results at conference
3. Development of PCR enabling users to detect pathogen populations in real-time instead of five to six weeks.

Major successful outcomes of the project include:
1. Identified four *Pythium* species in calla lily fields.
2. Identified a new pathogenic species, named *Pythium araceacium*, which is collected by American Type Culture Collection. Sequences of three molecular makers (cox1, cox2 and ITS) of the pathogens are submitted to National Center for Biotechnology Information.
3. Developed real-time PCR to detect and quantify soil pathogenic pathogens.
4. Presented project data in 2014 at the American Phytopathological Society (APS) meeting. (Phytopathology 104(Suppl. 3):S3.69). The annual meeting usually has 1500 – 3000 attendees which consist of professional Plant Pathologists as well as graduate students.
5. Prepared two manuscripts for submission in Plant Disease. Plant Disease is one of the scientific journals published by APS and is a peer reviewed journal. The first paper will be titled, “Pythium Araceacium: A New Species Causes Root Rot of Zantedeschia Hybrida in California.” The second paper will be titled,

"Quantification of Soil Populations of Pythium Araceacium by Real Time PCR." This process takes a long time and it is anticipated that the manuscripts will be published in 2016.

6. Presentations to growers were completed. One-on-one discussion were held with 3 representatives of Golden State bulb Growers.

Beneficiaries

The growers of calla lilies are the beneficiaries of this research. The cut flower or other crop growers can utilize real-time PCR to detect and quantify soil pathogens, which help them to make decisions on land rental and soil fumigation. Other researchers who chose to study this disease will also benefit from this research.

California has approximately 275 cut flower growers and about 5,000 acres of land area that is used to grow commercial cut flowers, producing a farm-gate value of $286 million.

Lessons Learned

1. To avoid delays on similar projects, staff should estimate the amount of time to execute a grant agreement, recruit staff, and set up money transfers and account for that time in the project's work plan timeline so that all activities can be completed in the timeframe allotted.
2. Staff planned to use seeds that had been stored for several years, but the germination rate was very slow and the percentage of the seeds that did germinate was low. To remedy this staff had to acquire and plant new seeds which delayed the project.
3. To identify new species of *Pythium* species: Staff used cox2 gene as molecular makers to identify known species. To identify new species, staff used three maker genes cox1, cox2 and ITS and confirmed the new species is emerged.
4. DNA extraction form soil samples: To remove soil inhibitors for real-time PCR application, several DNA extraction methods were used and compared. Power Soil® DNA Isolation Kit (MO BIO Laboratories, Inc. Carlsbad, California) was selected to extract soil DNA, which can be used by real-time PCR to detect and quantify pathogens in soils.
5. Real-time PCR application: Staff used regular real-time PCR to detect *Pythium* species, basic background contamination always existed. To remove basic contamination, staff designed specific probes and primers to detect and quantify soil samples using TapMan real-time polymerase chain reaction buffer (Life Technologies).

Additional Information

Staff anticipate the two manuscripts will be published on the APS Journals website in 2016: http://apsjournals.apsnet.org/loi/pdis

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 57	**Project Title:** Develop Management Strategies by Investigating the Mechanisms of Pathogenesis and Natural Defense Responses of Citrus Greening (HLB)

Grant Recipient: University of California, Riverside	**Grant Agreement No.:** SCB12057	**Date Submitted:** December 2015
Recipient Contact: Hailing Jin	**Telephone:** (951) 827-4968	**Email:** Hailing.Jin@ucr.edu

Project Summary

Huanglongbing (HLB, also known as citrus greening), one of the most destructive citrus diseases, has been the major threat to the global citrus industry. The pathogen that causes HLB, the bacteria '*Candidatus*' Liberibacter asiaticus' (CaLas) is vectored by the Asian citrus psyllid (ACP), which resulted in a significant reduction in both citrus quality and quantity. HLB causes billions of dollars in losses of citrus products every year, and seriously impacts the viability of the specialty crop citrus industry. To prevent its further spread, early diagnosis before the dreadful symptoms appear is particularly important. However, the facts that the bacteria cannot be cultured *in vitro* and their low and uneven concentration in hosts make HLB infection extremely difficult to detect. Up to now, partial control is mainly achieved by removal of infected trees and chemical treatment against the insect vector. No efficient and sustainable disease control methods for HLB have been found due to the lack of an adequate understanding of the mechanisms of pathogenesis and host responses, and the lack of efficient early diagnostic tools. Instead of attempting to detect the CaLas bacteria directly, the project team focused on host rapid defense responses to identify specific host biomarkers for early diagnosis of HLB. The most attractive strategy is to utilize host natural defense responses to limit damage from HLB. Small RNAs (sRNAs) are essential regulators of plant immunity against various pathogens. Some endogenous plant sRNAs are rapidly and specifically induced by pathogens, making them one of the most attractive markers for early diagnosis. At the same time, they are also important gene expression regulators for plant defense, which will lead to identification of host immune regulators for natural defense against HLB, which will contribute to develop effective means for natural disease control.

After HLB had been discovered in Florida, 2005, and started to spread in the United States, annual HLB management-related expenses reached 1.2 billion dollars. The most attractive long-term, sustainable, and desirable disease management is the utilization of natural defense mechanisms existing in host plants. The project team aimed to discover markers that responded in tolerant citrus cultivars. The optimal goal is to develop HLB specific early diagnostic markers and to understand specific sRNAs that regulate natural defense responses against HLB, which will contribute to development of disease management systems for disease control and even for recovering HLB-infected tree or even bacteria elimination.

After HLB had been discovered in Florida in 2005, and started to spread in the United States, annual HLB management-related expenses reached 1.2 billion dollars. The most attractive long-term, sustainable, and desirable disease management is the utilization of natural defense mechanisms existing in host plants. The project team aimed to discover markers that responded in tolerant citrus cultivars. The optimal goal is to develop HLB specific early diagnostic markers and to understand specific sRNAs that regulate natural defense responses against HLB, which will contribute to development of disease management systems for disease control and even for recovering HLB-infected trees or even bacteria elimination.

The project did not build on a previously funded Specialty Crop Block Grant Project.

Project Approach

The strategy was identifying small RNAs that specifically responded to HLB for understanding the pathogenesis and regulators involved in disease defense response. The objectives and deliverables are as follows:

Objective 1: Validate these small RNA markers using different citrus varieties collected from various locations. According to previous findings, project staff identified miR159 and miR399 as specifically induced by HLB, but not by Spiroplasma. This property shows the potential for developing into early diagnosis markers. The citrus materials collected from different citrus varieties from different locations have been tested, including controlled facilities, Contained Research Facility – University of California, Davis (CRSF-UC Davis), and citrus fields (Florida, California, and Texas).

Objective 2. Identify HLB-regulated small RNAs and genes (mRNAs) from US-942 (HLB-tolerant) and Cleopatra (HLB-sensitive). HLB-infected citrus materials were prepared by the co-Principal Investigator's (PI) Lab, United States Department of Agriculture-Agricultural Research Service (USDA-ARS), Fort Pierce, Florida). Project staff compared small RNA profiling between HLB-tolerant (US-942 and US-897) and HLB-sensitive (Cleopatra as sweet orange) citrus varieties that were infected with HLB. In the laboratory 108 RNA samples were inoculated and prepared as the following: For the grafting-inoculated HLB experiment, project staff used CTV-inoculation as a control for identifying HLB specific responded small RNA. Each RNA pool was extracted from 1.5 grams of stem/leaf tissue: There were 4 treatments (HLB-mock, HLB-infected, CTV-mock, CTV-infected), 3 genotypes (Cleo, US-897, US-942), 3 time points of Weeks Post Inoculation (7 wpi, 14 wpi, 28 wpi), and 3 biological replicates per treatment and varieties (4 x 3 x 3 x 3 = 108). There were 108 samples in total.

Small RNAs were extracted and small RNA libraries were constructed; then performed next-generation sequencing with Hi-seq Illumina Sequencer provided by University of California, Riverside (UCR) core facility. Project staff have completed 60 small RNA libraries with 2 replicates of each treatment (Table 1).

Table 1. Construction of small RNA libraries to identify HLB-specific responded regulators.

	Cleopatra (HLB-sensitive)		US-897 (HLB-mild tolerant)		US-942 (HLB-tolerant	
7 wpi	Mock	HLB	Mock	HLB	Mock	HLB
	Mock	CTV	-	-	Mock	CTV
14 wpi	Mock	HLB	Mock	HLB	Mock	HLB
	Mock	CTV	-	-	Mock	CTV
28 wpi	Mock	HLB	Mock	HLB	Mock	HLB
	Mock	CTV	-	-	Mock	CTV

Each treatment with 2 library replicates.

Objective 3. Identify, validate and functionally characterize the US-942-specific small RNAs and genes. The analysis of deep sequencing data of HLB-inoculated samples and identify a group of small RNAs and mRNAs in silicon has been completed.

The genome sequences for two citrus varieties –Project staff took the advantage of the releasing citrus genome sequences (sweet orange and Clementine mandarin genome have been finished and assembled in an international effort led by University of Florida) for sequencing analysis. Comparative analysis was performed between the datasets generated from tolerant and sensitive libraries and identified sets of HLB-induced small RNAs and genes that are specific to tolerant or sensitive varieties. The project team identified hundreds of small RNA having high expression level in HLB-inoculated samples (Table 2).

Those unique to US-942 and common appeared in US-942 and US-897 has high possibility involved in HLB-resistance mechanism.

Table 2. Amounts of small RNA specific induced by HLB in different citrus varieties.

	7 wpi	14 wpi	28 wpi
Cleopatra	939	1101	476
US-897	1840	237	619
US-942	1152	143	918
Unique in US-942	903	74	780
Common in US-942/897	240	56	168

One hundred small RNAs have been chosen that have more than 30 reads in at least one library and are differentially represented in tolerant and sensitive libraries for analysis. Five small RNAs responded to HLB in different varieties from the in silicon analysis (Table 3). The detailed information on sRNAs that are specifically induced in the susceptible genotype Cleo or in the tolerant genotype US-942 and US-897 is shown in Table 1. The detailed list of sRNAs that are common to Cleo and 942 and 897 is shown in Table 2.

Table 3. Small RNAs responded to HLB in different citrus varieties from small RNA library comparison.

Variety	**Sequence (5’→3’)**	**Target gene**
Cleopetra	TTGAGACACCATTCGAGCTAG	Calcium-dependent phosphotriesterase superfamily
	TTCTTATTCAGTGACTGTTTA	Stress Induced gene
	TTGTAAGACCTTTTCTTGACCT	Trans-Acting-siRNA
	TGATATGATCTGTTACTTGTT	Zinc ion binding
	TCAGGATATGGTTTTGATAAT	Transducin /WD40

US-897	TTCTTTGTGGTAGATTGTTTGC TTT	F-box family protein
	TAGCAGGTCGTGTGATACTTTG GG	Zinc Finger with HAT
	TTCGGACCCGTTACGACAATAA AT	Thaumatin superfamily protein
	TTGGATAAGGAATCAGAAAGG AGG	Disease Resistance Protein
	TCGATTAGAGATCTCTCAACTT GGCC	bHLH TF
Unique in US-942	AGACCTTCGGAATTTGAAGCT	WRKY Protein
	AGGGACAGTGAGATTCAAGA ACTT	Resistance Protein
	TTGAAGTGTTTGGAACTC	Disease Resistance protein
	AGACCTTGGGAATTTGAAGCT	WRKY DNA Binding
	CTGAAGTGTTTGGGGGAACTC	sulphur transporters and ATP sulphurylases (miR395)
Common in US-897/942	TCCAAAGGGATCGCATTGATT T	Mi393
	TCGCCGCGATCGTGGCTGGCA GCG	copper superoxide dismutases (mi398)
	TTTCTCTTATCGTTATCTGTGT	U-box Protein Kinase
	ACAGGAGGTGGAACAAATATG AAA	ZWI protein
	CTTGGGAACTGTGACATATGG	O-fucosyl-transferase

Objective 4. Analyze these components in comparison with citrus tristeza virus (CTV)-infected plants to understand their role in natural defense responses, which will help develop resistant/tolerant rootstocks. The small RNA libraries of CTV-infected citrus with both HLB-sensitive and tolerant varieties have been completed. Project staff has completed small RNA sets that differentially responded to CTV (Table 4). The detailed information on CTV regulated sRNAs is shown in Supplemental table 3.

Table 4. Amounts of small RNA specific induced by CTV in different citrus varieties.

	7 wpi	14 wpi	28 wpi
Cleopatra	1625	262	874
US-942	60	67	13

Five examples of small RNAs responded to CTV in different varieties from the in silicon analysis (Table 5). The details of sRNAs information that response to CTV in different time points from Cleopetra and US-942 are shown in Supplementary Table 1.

Table 5. Small RNAs responded to CTV in different citrus varieties from small RNA library comparison.

Variety	Sequence (5'→3')	Target gene
Cleopetra	GAACGGCGATCATCAGGATGGT	exocyst subunit exo70 family
	CGGACTCGAAACTGGTGTGACT	Toll-Interleukin-Resistance (TIR) domain-containing
	CTGTATAGACCACACATGGTTGA GGGTTGTA	Disease resistance-responsive (dirigent-like protein)
	AGTGTGCGTGGATTGTGGTAGA	RNA helicase family protein
	TTCCACAGCTTTCTTGAACTG	Growth Regulating Factor (GRF) transcription factors, rhodenase-like proteins, and kinesin-like protein B (mi396)
US-942	TGCGGATTGCGGCGGCGGCCC	C2H2 zinc finger TF
	CATTTTTGGTAAGCAGAACT	Reverse transcriptase like protein
	GCACAATTGGTCATCGCGCT	Disease Resistance protein
	CAGCCAAGGATGACTTGCCGGA GC	CBF-HAP2-like proteins (mi169)
	TCGCCGCGATCGTGGCTGGCAG CG	copper superoxide dismutases (miR398)

Comparing the sRNA pools that common induced by HLB in tolerant varieties, US-942/897, and by CTV in US-942, project staff identified unique induced by HLB or commonly induced by HLB and CTV (Table 4). The sRNA pool unique response to HLB reveals the natural defense mechanism specific for HLB. The common response pool for HLB and CTV indicates the defense mechanism for multiple pathogens.

Table 6. Small RNAs responded to HLB but not CTV or commonly induced by HLB and CTV in US-942 from small RNA library comparison.

	Sequence (5'→3')	Target gene
Unique induced by HLB	TTTGGATTGAAGGGAGTTTTT	MYB protein (mi159)
	TCCAAAGGGATCGCATTGATTT	F-box proteins and bHLH transcription factors (mi393)
	GGCCTTAACTGTTGACCTGTAG	E2F transcription factor 3
	TTTCTCTTATCGTTATCTGTTCT	MYB29 transcription factor
	TTGTCGCAGGAGCGTTGGCACC	MATE efflux family protein
Commom induced by HLB and CTV	GTGTTGGCAATGAAAATCTGG	WRKY DNA-binding protein 49
	TCGCCGCGATCGTGGCTGGCAGCG	copper superoxide dismutases (miR398)
	TAACTGCGGAGTTCTGATGGGATC	DHHC-zinc finger protein

The overall scope of this project solely benefited the specialty crop citrus industry.

The co-principal investigator provided the citrus material with HLB and CTV infection, and extracted total RNA from these trees, because project staff couldn't directly work on HLB positive plant material. An Associate Extension Specialist from UC Riverside, provided citrus material with various pathogen infections (mainly CTV) collected from California.

Goals and Outcomes Achieved

Goals and outcomes for each objective is showed as following:
Objective 1: Validate these small RNA markers using different citrus varieties collected from various locations.

Project staff tested the citrus plant materials collected from different citrus varieties (including sweet orange, mandarin, grapefruit, lemon, etc.) from different locations, which include the samples collected from Florida, Texas, and Southern California (provided by Citrus Research Board), with miR399, and siRNA markers, such as siRNA1005 and siRNA1009, that were identified. The results were promising. These primary sRNA markers are sensitive for detecting HLB-positive trees.

Objective 2. Identify HLB-regulated small RNAs and genes (mRNAs) from US-942 (HLB-tolerant) and Cleopatra (HLB-sensitive).

Project staff has completed the sRNA libraries of HLB-sensitive and tolerant cultivars with HLB infection in different time points. We have identified panels of sRNA that specific induced by HLB in HLB-sensitive and tolerant citrus cultivars for understanding the HLB resistance response and mechanism. (Table 7, also see table 2, 3, 6 and Attachment 1 and 2).

Table 7. sRNA as HLB diagnosis marker candidates. Up regulated sRNA common responsed to HLB in both tolerant variety US-942 and susceptible variety Cleopetra but not CTV infection. The difference expression level is set up as greater than 3 fold as selection threshold.

Variety	Sequence (5'→3')	Target gene	Fold Change (7/14/28 wpi)
Common up regulated in Cleopetra and US-942	TTTTTCCCACACCTCCCATCCC(csi-miR472)	disease resistance protein (CC-NBS-LRR class)	-/-/57.28
	TCCCTACTCCACCCATGCCATA	disease resistance protein (CC-NBS-LRR class)	-/-/28.44
	AGAACAGAGGGTGGCGTTGGCT (csi-miR398)	copper superoxide dismutases	-/4.56/7.94
	CGAGAATCTACCCGCGGACGT	unknown	-/3.70/4.89
	CAGCTCGCGTTGACTACGTCCC(csi-miR-3951)	DNA binding / DNA-directed RNA polymerase	-/-/3.13

Objective 3. Identify, validate and functionally characterize the US-942 specific small RNAs and genes.

Project staff identified a group of small RNAs in silicon specific response to HLB in HLB-tolerant varieties. The sRNA group that common appeared in HLB-tolerant cultivars US-942 and US-897 are important clue for understanding the resistant mechanism for identifying the master regulators.

Table 8. Up or down regulated sRNA unique in HLB tolerant varieties US-942/US-897 but not in HLB susceptible variety Cleopetra. The difference expression level is set up as greater than 3 fold as selection threshold.

Variety	Sequence (5'→3')	Target gene	Fold Change (US-942/US-897)
Up regulated in US-942/ US-897 but not in Cleopetra	AAGCTCCCCATCGTCGTTGACTGA	Calmodulin binding protein	9.13/5.25
	CCCGAACCGAACCGAACCCGAAAT	vacuolar sorting protein 9 domain-containing protein	4.98/6.06
	AGCATGGAGATGGAGGGAGGGATG	CCAAT-binding transcription factor	4.97/3.31
	ATTCCTTAACTAACAATTTATAG	Calmodulin-dependent protein kinase	5.59/3.28
	TTTCTCTTATCGTTATCTGTTC	Protein kinase family protein	5.56/8.68
Down regulated in US-942/ US-897 but not in Cleopetra	ATTTGATTTGTCTCGTCGTAAGCT	inter-alpha-trypsin inhibitor heavy chain-related	-3.27/-3.78
	TCCGAAGAAGTCGTTGATTGA	disease resistance protein (TIR-NBS-LRR class)	-4.86/-3.00
	AAGGAGTGGGAGACAAAGTTTGTT	family II extracellular lipase	-5.43/-3.00
	GGTTGGGAATGAGAATGTGAGAAT	multidrug resistance-associated protein	-4.92/-3.05
	CGGGGGTGACGGGGATGACGGATT	tonoplast-localized receptor-like kinase	-4.82/-3.03

Objective 4. Analyze these components in comparison with citrus tristeza virus (CTV)-infected plants to understand their role in natural defense responses, which will help develop resistant/tolerant rootstocks.

Project staff completed the small RNA libraries of CTV-infected citrus with both HLB-sensitive and tolerant cultivars. Project staff compared to small RNA candidates form HLB-infected pool and have the groups: 1) common induced by both HLB and CTV; 2) specific induced by HLB. Though CaLas and CTV are both phloem-restrict pathogens in citrus, sRNA profiles revealed that sRNAs responses to CaLas and CTV are quite different. These comparisons will reveal roles of these regulators playing in natural defense. These sRNAs could be developed into biomarker for resistant varieties selection. The specific responded sRNAs would be developed to diagnose biomarkers as the short-term goal of this project. (See table 4, 5, 6 and Attachment 3).

Overall project staff identified the sRNA candidates that responded to HLB and CTV from HLB-sensitive and tolerant cultivars *in silicon*. The long-term goal is thorough validation of these panels of sRNAs and identifying the natural defense mechanism for HLB disease management.

The major goals have been completed, the project team has constructed, sequenced and analyzed all the libraries and identified panels of sRNA in silicon analysis with: 1) specific responded to HLB in HLB-tolerant citrus cultivars; 2) common responded to CTV and HLB and specific to HLB. All analysis has been completed and a list of sRNA candidates is available. (See table 6, 7, 8 and Attachments 1, 2 and 3).

The major successful outcomes of this project are:

1. Completed 36 HLB-infected sRNA libraries including HLB-sensitive cultivar, Cleopetra, and HLB-tolerant cultivars, US-942 and US-897.
2. Completed 24 CTV-infected sRNA libraries with HLB-sensitive cultivar, Cleopetra, and HLB-tolerant cultivars, US-942.
3. Completed the in silicon analysis and identify panels of specific responded sRNAs.

Beneficiaries

Over 4,500 California specialty crop citrus growers are the direct beneficiaries from the completion of this project's accomplishments, as well as California's specialty crop citrus industry.

The identified HLB-specific induced small RNAs can be developed as early diagnostic markers which will benefit not only the specialty crop citrus growers in California, Florida, and Texas, but also to the whole citrus industry in the US and the world.

The identified small RNAs and genes that are specific to tolerant/resistance varieties are likely to be used to develop tolerant/resistance citrus plants and rootstocks as new and commercially important varieties which will help all the citrus growers, and ultimately benefit the whole citrus industry nationally and internationally.

Lessons Learned

The project team conducted large amounts of sRNA libraries construction. The project team learned that good quality and quantity of RNA is essential for constructing a successful and representative library.

Additional Information

See Attachments 1-3

USDA Project No.: 58	**Project Title:** Creating New Weed Management Tools for Lettuce and Spinach Production in California	
Grant Recipient: United States Department of Agriculture, Agricultural Research Service (USDA-ARS)	**Grant Agreement No.:** SCB12058	**Date Submitted:** December 2015
Recipient Contact: Beiquan Mou	**Telephone:** (831) 755-2893	**Email:** beiquan.mou@ars.usda.gov

Project Summary

California is the main region for fresh spinach and lettuce production in the United States. Even though these crops are sensitive to weed competition, they have problematic weed control systems. Fresh spinach and lettuce have only a few available herbicides, but those do not provide adequate weed control. For commercially acceptable weed control, growers have become highly dependent on hand weeding. However, the shrinking farm labor pool plus the aging demographics of farm workers has resulted in labor shortages and higher wages paid to attract and retain experienced farm workers. This trend is not sustainable and threatens profitable production relative to foreign countries with lower labor costs. The herbicide industry has no incentive to develop or register new herbicides for leafy vegetables due to their relatively small acreage and economic return. To reduce hand-weeding costs and remain economically sustainable in the long-run, fresh spinach and lettuce producers need to adopt alternative weed control strategies.

Biotechnology and genetic modifications have the potential to improve current weed control systems of vegetable crops. The advantage of herbicide-tolerant crops is that a single herbicide can effectively control most weeds without harming crop plants. However, transgenic vegetables might be rejected by consumers in the United States and in Europe, and for that reason, such varieties are currently avoided by the industry. Chemically induced mutations, using chemicals like ethyl methane sulfonate (EMS), have been successfully utilized to develop improved vegetable varieties. This breeding approach seems to be a promising alternative that can avoid the antagonist public opinion which is associated with transgenic crops. Therefore, the main objective of this study was to create sustainable weed management systems by identifying and developing herbicide tolerance in fresh spinach and lettuce germplasm in EMS mutated populations and to evaluate their level of tolerance.

In general, adopting “new” herbicides for fresh spinach and lettuce production is of great interest. These crops have few herbicide options which are limited in weed spectrum. Linuron is very effective for many annual broad-leaved weeds which are typical for the coastal areas of California. It can be applied pre-emergence and post-emergence, which can improve lettuce and spinach growers’ flexibility and application options, as these crops do not have post-emergence herbicides. This would allow improvement in current weed control programs for these crops, which in turn can reduce hand weeding costs and the high dependency on human labor. In addition, this herbicide is already registered and used in other vegetable crops like celery and carrots, which would make it suitable for local cropping systems (crop cycles).

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

In the first year of this project, project staff treated lettuce seeds with EMS and grew the novel generation (M0). By the end of Year 1, project staff had seeds of the first generation (M1) ready for the selection process. In Year 2 of the project, the selection processes for the M1 seeds for Linuron resistance were made. Project staff also treated spinach with EMS, grew the M0 generation, and started the screening process for the M1 spinach seeds.

Project staff conducted preliminary experiments to test the conditions of the seed treatment and different concentrations of EMS. EMS-treated M0 lettuce and spinach seeds were planted in flats filled with potting mix before being transplanted into 3-inch pots to generate seeds for screening in the next generation. Project staff planted about 9,000 M1 lettuce plants (grown in the flats) in pots in the greenhouse to generate second generation (M2) mutant seeds for herbicide resistance screening. Because many mutant plants were sterile, only about 3,000 plants were harvested and about 1,500 of them contained seeds. All 1,500 lettuce M2 mutant lines were screened for resistance to a pre-emergence herbicide, Linuron, and a post-emergence herbicide, bromoxynil. One M3 bromoxynil resistant lettuce plant was identified; however, this plant died from disease in the greenhouse before setting seeds.

About 3,000 spinach M1 plants were planted in pots in a greenhouse to generate M2 seeds for herbicide resistance screening. Individual spinach plants were bagged to prevent cross-pollination. About 800 spinach M2 mutant lines were screened for resistance to Linuron. 50 third generation (M3) Linuron resistant spinach plants were identified and harvested for seeds. Large amounts of seeds were planted for segregation analysis. The pots were treated with Linuron and numbers of resistant and susceptible plants were counted. Results were not clear, as lines did not show consistent tolerance for the herbicide. At this point, project staff do not have a germplasm with definitive tolerance for Linuron.

SpinAid (phenmedipham) is a post-emergence herbicide for grasses and broadleaf weeds registered for use on spinach grown for processing or seed, but not for use in fresh spinach production. Project staff evaluated the potential use of SpinAid alone and in combination with Cycloate for weed control in fresh spinach production. Field studies were conducted in 2013 using two spinach varieties know to have low and high tolerance to SpinAid. SpinAid alone (550 g ha^{-1}) did not result in crop injury when applied to four-leaf spinach; however, the weed control was not better than Cycloate alone. When applied as a sequential treatment following Cycloate, all SpinAid rates (90, 180 and 270 g ha^{-1}) were safe to spinach and significantly improved weed control compared to Cycloate alone. Cycloate followed by SpinAid at 270 g ha^{-1} provided 87% weed control relative to Cycloate alone. This level of weed control was similar to the Cycloate plus hand weeding treatment, which provided 98% control. Results here show that Cycloate followed by SpinAid improves weed control compared to Cycloate alone, and has the potential to reduce hand-weeding costs in the fresh spinach production.

Because spinach has a short growth cycle (33 days in mid-summer in central California) and SpinAid has a 21 day pre-harvest interval (PHI) requirement in the product label, the sequential application of Cycloate and SpinAid is not useful for most of spinach growing season; the crop is often ready to be harvested before the PHI expires. SpinAid must be applied at the earliest growth stage possible that is safe for spinach. Therefore, the potential application of Cycloate pre-emergence followed by SpinAid at the two-leaf stage for weed control in fresh spinach was evaluated. In addition, the potential of evening applications to increase SpinAid safety for spinach was evaluated. Field studies were conducted in 2014 using two spinach varieties known to have low and high tolerance to SpinAid. SpinAid (550 g ha^{-1}) applied in the evening was found to be safer for spinach than in the morning. The main differences were observed in the first three days after treatment injury evaluation. Project staff concluded that the evening application timing is favorable.

When applied in the evening at the two leaf stage as a sequential treatment following Cycloate, all SpinAid rates (90, 180 g ha^{-1}) were safe to spinach and significantly improved weed control compared to Cycloate alone. Cycloate followed by SpinAid at 180 g ha^{-1} provided 88% weed control relative to Cycloate alone. This level of weed control was similar to the Cycloate pre-emergence plus SpinAid (270 g ha^{-1}) applied at the four-leaf stage, which proved high effectiveness in the 2013 studies. Results here show that Cycloate followed by SpinAid can be an effective treatment throughout spinach growing season, as this treatment improves weed control compared to Cycloate alone and has the potential to reduce hand-weeding costs in the fresh spinach production. Results from this experiment were summarized in manuscripts and were submitted to the Weed Science and Weed Technology journals.

Experiments were also performed to test 20 spinach cultivars for tolerance to the SpinAid herbicide in two field tests and greenhouse tests. Yield and physiological traits like fluorescence and chlorophyll content were measured to find differences among the cultivars. Fresh spinach tolerance to SpinAid differed by variety, and dry weights of treated plants ranged from 40% to 78% compared to the control. The dry weights of the less tolerant varieties, Tyee and Nordic, were approximately half that of Santorini and Regal, the most tolerant varieties. These results indicate that there is a range in tolerance of fresh spinach varieties to SpinAid. These findings can be utilized to improve weed control programs in this crop. Fresh spinach does not have post-emergence herbicides for broadleaf weeds, and the agrichemical industry has no incentive to develop or register new post-emergence herbicides due to its small hectarage and high costs. Identifying varieties with a high tolerance level for non-labeled herbicides may offer “new” herbicide options in the tool set available for weed management in fresh spinach. If necessary, registration of this “new” herbicide can be variety-specific. Since SpinAid and Cycloate have different modes of action (MOA), a sequential application of these herbicides can increase the spectrum and efficacy of controlled weeds and allow MOA rotation. Furthermore, data about genetic diversity in the tolerance level for SpinAid (or any other herbicide) across varieties can also be useful for plant breeders. Considering herbicide tolerance early in the selection process of new varieties can lead to high tolerance levels in the end of the process, which in turn may enable herbicide applications at higher rates and better weed control. The 22% dry weight reduction of Santorini and Regal treated with SpinAid should not discourage future development of SpinAid-based programs for fresh spinach. Other studies reported that significant yield reductions in fresh spinach resulted from Cycloate applied under high temperature conditions. In addition, this study included full SpinAid rate (0.55 kg ha^{-1}), whereas Lati et al. (2015) used a lower rate (0.27 kg ha^{-1}) following Cycloate pre-emergence, which was effective and did not cause spinach injury or yield reduction.

During the grant term, project staff tested as many herbicide products as they could given the available greenhouse space and time constraint. Prometryn (Caparol), Roundup, Lorox, and trieburon (Express) were not tested. The research only benefited lettuce and spinach, two important specialty crops.

The subcontractor for this project was the University of California, Davis (UCD). The Co-Project Director (Co-PD) from UCD along with the Project Director from USDA-ARS provided technical advice and student help for the Postdoctoral Research Associate from UCD, purchased necessary lab and greenhouse supplies, secured greenhouse spaces for the study, and managed the budget. The Postdoctoral Research Associate treated lettuce and spinach seeds with EMS, grew the M1 mutant plants for M2 seeds, screened lettuce mutants for herbicide resistance, conducted herbicide tolerance experiments for spinach, and summarized the data in papers and reports.

Goals and Outcomes Achieved

A major goal for this project was to screen lettuce and spinach germplasm and identify mutants and cultivars with herbicide tolerance. Progress was made by treating seeds with EMS, growing them in the greenhouse, and extracting seeds from lettuce and spinach. Project staff also studied the tolerance of spinach cultivars to different herbicides. Using this knowledge, new effective weed control methods for spinach production were designed. Research results were summarized in papers and published in peer-reviewed journals (see Additional Information). Two papers have been published and two more papers have been accepted for publication. Project staff demonstrated the research to growers, researchers, and California Leafy Greens Research Board members. About 80 people total attended the two demonstrations held in Salinas, California.

Because many mutant lines were sterile, project staff generated about 1,500 lettuce and 3,000 spinach germplasm lines. The project never got to the point of having herbicide-resistant products that needed registration. There was not a release of herbicide-tolerant lettuce and spinach varieties; however, project staff are still working on the breeding materials developed from the project and hope to release herbicide-tolerant germplasm in the near future.

A long-term goal of the project was to be judged by the percentage of lettuce and spinach acreage planted with herbicide-tolerant cultivars in California. This was to be measured by mail and telephone surveys of seed companies for the percentage of lettuce and spinach seeds sold with the herbicide-tolerant trait three years after the completion of the project; however, herbicide-tolerant lettuce and spinach varieties have not yet been developed, but project staff are still working towards this goal.

Project staff generated lettuce and spinach mutant lines. Although project staff did not find herbicide-resistant lines, the lines generated are a great starting point for future research. Future screening projects for these lines can yield a resistant line that will improve the productivity and the competitiveness of lettuce and spinach.

The SpinAid-based weed control management project staff developed for fresh market spinach is a huge contribution for the production of this crop. It offers growers a post-emergence herbicide tool that was not available in this crop so far. This “new” herbicide can be integrated into current weed control programs in fresh spinach and improve them. These research findings offer for the first time a post-emergence herbicide tool for fresh spinach production that is safe, effective, and can be used throughout the growing season. Using this new management method can reduce hand-weeding costs, the high dependency growers have for human labor, and therefore, enhance the competitiveness of these crops.

Beneficiaries

The beneficiaries of this project are California lettuce and spinach producers who may be able to lower weed control costs, realize improved weed control, and reduce dependence on hand labor. There are 107 lettuce, 67 spinach, and 25 spring mix producing companies, as well as more than 30 seed companies, in California. Farm workers may benefit by reduced incidence of injury from repetitive work. Consumers may benefit by the availability of less expensive lettuce and spinach products.

Lettuce in California is grown over 81,000 ha with hand weeding expenses of $80 ha^{-1}, for a total of $6,480,000. Pronamide (the standard herbicide) provides about 40% weed control. Complementary herbicides like Linuron that can improve weed control up to 100% control can save this entire amount. However, more modest evaluations of 70% savings in hand weeding costs would translate to $4,480,000 in savings for California lettuce growers.

Spinach in California is grown over 15,000 ha with hand weeding expenses of $84 ha^{-1}, for a total of $1,260,000. Cycloate (the standard herbicide) provides about 50% weed control. Complementary herbicides like Linuron that can improve weed control up to 100% control can save this entire amount. However, more modest evaluations of 80% savings in hand weeding costs would translate to $1,008,000 in savings for California spinach growers.

Furthermore, the SpinAid project that has already been completed can improve weed control by 88%. Rough estimation of 60% reductions in hand weeding times means $756,000 savings for California fresh spinach growers that can be currently achieved.

Lessons Learned

The use of Spin-Aid was not part of the main project; it was complementary in approach to improving weed control in spinach. The idea of using non-registered herbicide for this crop and evaluating possible integration and its safety for spinach was an idea made by the Project Director and Co-Project Director. In the future, project staff suggest to screen more "non-registered" herbicides and to evaluate safety on large number of lines. Integrating "new" herbicides for the limited herbicides available for these crops can save a lot of money for growers.

Breeding projects are long. Two years and nine months is just not enough to complete this kind of project. The time for lettuce to produce seeds in M1 was 10 months, and another 10 months to complete the M2 screening. Growing these plants in the greenhouse was highly time consuming and took a lot of labor. It did not leave much time for the spinach project. It also took about six months to hire the Postdoctoral Research Associate for the research work.

The new Spin-Aid based management for fresh spinach was unexpected. It was a significant outcome and provides an actual tool for weed control in this crop that can be used soon (with only registration issues). The large spectrum of fresh spinach lines with tolerance to Spin-Aid (and possibly other herbicides) is another unexpected result. It can be used as a good starting point for breeding projects in the future or motivate new herbicide tolerance screening projects.

A lesson learned that could help others expedite problem-solving on this type of project in the future is to focus on one crop. For crops with long crop-cycles like lettuce, more time is essential.

Additional Information

The project has generated the following publications so far:

1. Lati, R. N., J. S. Rachuy, and S. A. Fennimore. 2015. Weed Management in Fresh Market Spinach (*Spinacia oleracea*) with Phenmedipham and Cycloate. Weed Technology 29:101-107.

2. Lati, R. N., B. Mou, J. S. Rachuy, R. F. Smith, S. K. Dara, O. Daugovish, and S. A. Fennimore. 2015. Weed management in transplanted lettuce (*Lactuca sativa* L.) with pendimethalin and *S*-metolachlor. Weed Technology 29: 827-834.
3. Lati, R. N., B. Mou, J. S. Rachuy, and S. A. Fennimore. 2015. Light Intensity Is a Main Factor Affecting Fresh Market Spinach Tolerance for Phenmedipham. Weed Science (*in press,* accepted on July 25, 2015, DOI: 10.1614/WS-D-15-00056.1)
4. Lati, R. N., B. Mou, J. S. Rachuy, and S. A. Fennimore. 2015. Evaluation of Cycloate Followed by Two-Leaf Stage Phenmedipham Application in Fresh Market Spinach. Weed Technology (*in press*, accepted on November 12, 2015, DOI: http://dx.doi.org/10.1614/WT-D-15-00102.1)

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 59	**Project Title:** Development of a biological control agent for snail and slug pests of nursery plants in California	
Grant Recipient: The Regents of the University of California, Riverside	**Grant Agreement No.:** SCB12059	**Date Submitted:** December 2015
Recipient Contact: Timothy Paine	**Telephone:** 951-827-5835	**Email:** tpaine@ycr.edu

Project Summary

Invasive gastropods (snails and slugs) are among the most important pests attaching California specialty crops, particularly nursery and greenhouse crops. They feed directly on plants, vector plant, and human pathogens such as Escherichia coli, and lower crop quality through fecal and mucus contamination. Current control options are impractical for large areas or cause damaging non-target effects. Management in California relies almost exclusively on molluscicides, with Metaldehyde being the current preventive standard practice. Although generally effective and efficient (death within 1 day), it is very toxic to pets such as dogs; and under high relative humidity, activity is lower and snails may recover. Iron phosphate and sodium ferric Ethylenediaminetetraacetic Acid (EDTA) are often used to manage snails and slugs during high humidity or where there are concerns about pet safety. Both materials act slower than metadehyde (2-7 days for death) and iron phosphate may be toxic to non-targets such as earthworms. Methiocarb is a restricted use molluscicide and is toxic to mammals including humans, birds, bees, and aquatic taxa; and is typically only used as an emergency control measure. Other control options such as copper barriers are impractical for large areas. There is, hence, an urgent need for more effective and safe strategies to manage pest snails and slugs in California specialty crops, particularly nursery and greenhouse crops, including floriculture.

This project is important because it aimed to identify a new control option for managing invasive gastropods in California nurseries. Specifically, the goal was to identify a potentially effective biological control agent for widespread use. The project was also timely because there is currently no biological control agent available for use against gastropods in California nurseries. Snails and slugs have a wide range of natural enemies but research on options for biocontrol has received little attention in the United States (US). Furthermore, the monoxenic combination of the nematode Phasmarhabditis hermaphrodita and its bacterial associate, Moraxella osloensis, is currently providing effective control of snails and slugs in a wide range of agricultural and horticultural crops in Europe (e.g. up to 100% reduction in gastropod damage to orchids). The product, is available commercially in Europe as Nemaslug®, and is lethal to many pest snails and slugs in seventeen families, notably Agriolimacidae, Arionidae, Helicidae, Milacidae, Limacidae and Veronicellidae which are also the main pest gastropod families in California. Many other potential markets for P. hermaphrodita, particularly in the US, have been identified but, because there are no confirmed reports of it being isolated here, legislation prevents its sale in US.

This project did not built on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Questionnaire design, testing and analysis occurred as follows:
Undergraduate and graduate recruitment and training was completed. During the course of this project, project team hired a number of undergraduate research assistants at no extra cost to the project. The Assistant

Specialist recruited one assistant to help with snail and slug colony maintenance. The Associate Specialist recruited four undergraduate assistants to assist with culture media preparation, isolation, and maintenance of nematode and bacterial cultures; preparation of semi-permanent nematode mounts for morphological examination and archiving; and Polymerase Chain Reaction (PCR)/molecular diagnostics. Two students were mentored through the University of California, Riverside (UCR) Science, Technology, Engineering, and Math (STEM) program; and one with the California Alliance for Minority Participation (CAMP). The Associate Specialist also mentored a PhD graduate student in the Microbiology and Plant Pathology program on bacterial isolation, maintenance, long-term storage, and molecular identification using 16S rDNA. All students were recruited at no extra cost to the project, they were fully integrated into the research and some of them are co-authors on project publications.

Gastropod collections were conducted throughout the course of the project, a total of forty-two gastropod collections were made in nurseries (wholesale and retail) and garden centers throughout California. Collections were made in Arroyo Grande (San Luis Obispo County.), San Clemente (Orange County), Chester (Plumas County), Cloverdale (Sonoma County), Eureka (Humboldt County), Fresno (Fresno County), Irvine (Orange County), Los Osos (San Luis Obispo County), McKinleyville (Humboldt County), Menifee (Riverside County), Mount Shasta (Siskiyou County), Moreno Valley (Riverside County), Oceanside (San Diego County), Orange (Orange County), Orcutt (Santa Barbara County), Redlands (San Bernardino County), Riverside (Riverside County), San Diego (San Diego County), San Mateo (San Mateo County), Santa Barbara (Santa Barbara County), Santa Cruz (Santa Cruz County), Sonoma (Sonoma County), Temecula (Riverside County), and Woodlake (Tulare County).

During the course of these surveys a total of 2,522 slug and snail specimens were collected and returned to the Insectary Facility at UCR under California Department of Food and Agriculture (CDFA) Permit 2942 for colony establishment and natural enemy screening. Project staff collected eleven slug species (Arion hortensis agg., Arion subfuscus, Arion rufus, Boettgerilla pallens, Deroceras invadens, Deroceras laeve, Deroceras reticulatum, Lehmannia valentiana, Limacus flavus, Milax gagates, and Prophysaon andersoni); and five snail species (Cornu aspersum, Otala lactea, Oxychilus sp., Rumina decollata, and Succinea sp.). The three most abundant species were the slugs D. reticulatum (625 specimens), L. valentiana (613 specimens) and Arion hortensis agg. (265 specimens) and these accounted for sixty percent of the total catch. Furthermore, more slug (1,998 individuals) than snail (524 individuals) specimens were collected, suggesting that the former are a more important pest of the nursery industry in California. In fact, slugs accounted for seventy-nine percent of the total catch.

There were two records of note among these collections. Firstly, project staff collected a specimen of A. subfuscus in Riverside County. This is the most southern record of this invasive species in California. Prior to this, it was only known north of San Mateo County. Secondly, the most significant gastropod that was collected during the surveys was Boettgerilla pallens (Figure 1). Project staff collected a specimen of this species under potted plants in a garden center in San Mateo (San Mateo County) on January 27, 2013 and it was the first record of B. pallens in the US. The identification was confirmed by morphological and molecular methods by the National Malacologist from United States Department of Agriculture (USDA)-Animal and Plant Health Inspection Service (APHIS)-Plant Protection and Quarantine (PPQ), and by a Research Scientist at USDA-APHIS-Center for Plant Health Science Technology (CPHST). During the 2014 year, a scientific note on the discovery of this species was published in the American Malacological Bulletin (Mc Donnell et. al. 2014 First report of the invasive slug Boettgerilla pallens Simroth, 1912 (Boettgerillidae) in the US.

American Malacological Bulletin 32: 209 – 210). Subsequent to the publication of this paper, project staff collected an additional specimen of B. pallens under potted plants in McKinleyville (Humboldt County) on August 6, 2014.

Figure 1. The invasive European slug, Boettgerilla pallens, collected in a garden center in San Mateo, California in January, 2013.

Permit application and natural enemy exploration in Europe was complete. A USDA import permit (P526P-13-02683) was issued to the Project Director in July, 2013 authorizing the importation of snail and slug killing parasitoids from Europe into the Biosecurity Level 2 Quarantine Facility at UCR. Europe was selected as the destination for natural enemy exploration because the gastropods collected in nurseries during this project were European invasive species; therefore, on issuance of the permit, the Assistant Specialist traveled to Ireland, Andorra, and Spain to collect potential biological control agents.

Since slugs appear to be the predominant gastropod pest in nurseries in California (based on the gastropod survey results), a high priority for the natural enemy exploration trip was to collect the slug-killing sciomyzid fly, Tetanocera elata, because the biological control potential of this parasitoid has long been recognized (Knutson et al., 1965; Knutson and Vala 2011). Another species of interest was Pherbella cinerella, which has been cited as having biological control potential against pest snails in agricultural systems in other parts of the world (Coupland and Baker 1995). Project staff were successful in collecting these two parasitoids and others of interest in Europe (Table 1), and harvested in excess of 1,000 eggs.

Table 1. Snail and slug-killing parasitoids collected in Europe during natural enemy exploration.

Location*	Parasitoid species	Number collected	Host
Ireland	Tetanocera elata	44	Slugs
	Tetanocera arrogans	1	Amber snails
Spain	Pherbellia cinerella	39	Terrestrial snails
	Coremacera marginata	1	Terrestrial snails
	Trypetoptera punctulata	2	Terrestrial snails

* Sampling was also carried out in Andorra but no parasitoids were found. This may have been due to the mountainous nature and high altitude of the country.

However, despite the best efforts and being in possession of a USDA import permit, it proved impossible to import these potential biological control agents and their eggs into the Quarantine Facility at UCR. The leading commercial carriers such as FedEx, DHL and UPS, refused to ship living insects. Project staff also approached local courier companies in Europe (e.g. DPD in Ireland) and an international freight company called SDV, but they were ultimately unable to assist. Although SDV has experience of shipping live insects into the US from France, they were unable to find partners in Ireland and Spain to handle the shipments in those countries. Once it became apparent that it would not be possible to import the parasitoids from Europe, the Assistant Research Specialist traveled to northern California to search for a native slug-killing fly called Tetanocera plebeja, which was reported from Inglenook Fen near Fort Bragg in the 1960's and 1970's. The larval stage of this fly is known to feed on pest slugs in the genus Deroceras. Extensive sampling of this site and others in early November, 2013 did not yield any specimens.

In an additional attempt to collect parasitoids of snails and slugs, the Assistant Research Specialist traveled to the states of Indiana and Illinois in May, 2014 to search for T. plebeja, Tetanocera clara and Tetanocera valida. During this trip, the Assistant Research Specialist was assisted in the field by an expert on slug and snail-killing flies, who has collected these species in multiple locations throughout Indiana and Illinois over the past five years. However, despite a week of intensive collecting, no specimens of the target species were collected.

Lastly, during a gastropod collecting trip to Northern California in August, 2014 the Assistant Research Specialist again attempted to collect T. plebeja. Although, this species was not found, the Assistant Research Specialist did collect the parasitoids listed in Table 2. These species were returned to the Insectary and Quarantine Facility at UC Riverside for biological control testing.

Table 2. Gastropod-killing fly species collected in Northern California during August 2014.

Species	No. specimens	Locations
Hoplodictya acuticornis	1	Dry Lagoon, Humboldt Lagoons State Park, Trinidad
Limnia inopa	1	Edge of Inglenook Fen, Fort Bragg
Limnia severa	11	Big Bear Flats, near Pondosa
	3	Edge of Inglenook Fen, Fort Bragg
Pherbella schoenherri maculata	1	Dry Lagoon, Humboldt Lagoons State Park, Trinidad
Sepedon borealis	3	Big Bear Flats, near Pondosa
Tetanocera plumosa	3	Edge of Heenan Lake, Markleeville

Biological control testing of arthropod natural enemies was conducted. Of the species listed in Table 2, Limnia severa and Tetanocera plumosa oviposited viable eggs in the laboratory. On hatching, neonate larvae were subjected to host acceptability testing, where a single larvae was presented with either a specimen of Lehmannia valentiana, Deroceras reticulatum, Deroceras laeve, Arion hortensis or Cornu aspersum. Although each bioassay was replicated ten times, none of the target gastropods were killed by the parasitoids, which suggests that they do not have biological control potential against these pests. For this reason, and given the success of the nematode, Phasmarhabditis hermaphrodita, as a biological control agent in Europe (commercially available as Nemaslug®), project staff decided to focus biological control efforts on the nematode species that were recovered from gastropods collected in California, specifically three species of Phasmarhabditis (including P. hermaphrodia).

Isolation, maintenance and identification of nematodes and associated bacteria was completed. Although project staff mainly emphasized nematodes in this objective, bacterial associates were equally important because the bacteria plays a critical play in the death of the infested gastropod. For that reason, project staff also isolated, cultured, and maintained bacterial associates, and used molecular sequencing for identification.

Nematodes isolation, culturing, and identification occurred as follows: Collected gastropods were maintained on organic carrots. Dead specimens were transferred to one percent plain agar (PA); and nematodes that emerged were isolated, sub-cultured, and subsequently maintained on fresh PA. Associated bacteria were streaked on nutrient agar (NA) and single colonies were isolated for identification. Over seven hundred dead gastropods were transferred to agar in nematode emergence assays. Of these, more than forty percent had associated nematodes, with more nematode occurrence in Southern California (57.7%) than in Northern California (27.2%). Nematodes were identified using reverse taxonomy. Specimens were morphologically archived (Video-capture and editing, De Ley and Bert, 2002) prior to PCR. Deoxyribonucleic Acid (DNA) sequencing of the D2D3 domain of the large subunit (LSU) and/or near complete small subunit (SSU) Recombinant (r) DNA revealed that the nematodes belong to at least twelve major groups that include Rhabditidae (Oscheius dolichura and *O.* tipulae; Caenorhabditis elegans), Diplogasterida (Protodiplogasteroides/Pseudodiplogasteroides), Cosmocercoidea/Ascaridae (Nemhelix bakeri, Krefftascaris sp) and Alloionematidae (Alloionema appendiculatum*)*. Basic Local Alignment Search Tool (BLAST), which is a nucleotide/protein sequence database, revealed few perfect matches to sequences already deposited in GenBank. When needed, specimens were processed to glycerin and mounted on semi-permanent microscope slides for morphological/morphometrical studies. All measurements were done by first video recording individual nematodes at different magnifications, choosing frames that show taxonomic structures, stitching these frames (Figure 2), measuring the length of structures (pixels/millimeter (mm)) in an image editing software (GIMP) and converting these values to micrometer (µm).

Figure 2. Adult male (above) and gravid female (below) of Alloionema appendiculatum (shown at same magnification, body length of female =2.35 mm).

A. appendiculatum (then designated as var dubia) was first reported in US in 1934 from Succinea avara in Piscataway, Maryland (Chitwood and McIntosh, 1934). In 2007, surveys of slug nematode parasites in the US (Ross *et al.*, 2010) yielded a low nematode recovery (5.4%) with the majority (10 of 14) of species of Rhabditidae unidentified. A. appendiculatum, although found most often (34% of all isolates), was reported only from Oregon (4 sites) and Washington (2) but neither of two sites sampled in California. The collections in 2013 produced A. appendiculatum from Deroceras reticulatum (4 isolates), Lehmannia valentiana (3), Arion hortensis (3) in San Mateo, California, and from Succinea sp (1) from Perris, California. Measurements of representative isolate one hundred and seventy-six confirmed that morphometrics are within the range of A appendiculatum. All isolates were genetically identical on the bases of their ITS rDNA and/or mitochondrial DNA, D2-D3 sequences and the more conserved SSU gene.

On August 21, 2013, project staff confirmed the presence of two Phasmarhabditis species in the nematode collection in addition to ten isolates of Alloionema appendiculatum. Project staff then focused on establishing cultures from single females. A third Phasmarhabditis species was later discovered. The finding is the first confirmed record of Phasmarhabditis hermaphrodita in North America (Tandingan De Ley, *et al.*, 2014). P. hermaphrodita and P. californiense were found only in Northern California from Eureka, Humboldt County, south to San Mateo County., while P. davidei was isolated only from a single specimen in San Diego County. (Table 3).

Table 3. Phasmarhabditis species, hosts and sampling locations in California

Phasmarhabditis spp	Host	Location
P. hermaphrodita	Deroceras reticulatum	Eureka (2x)
	Deroceras laeve	Sonoma
	Lehmannia valentiana	Eureka
P. californiense sp 1	Deroceras reticulatum	Sonoma (2x), Mckinleyville
	Arion hortensis	Eureka
	Deroceras laeve	Eureka
	Deroceras reticulatum	Eureka
	Lehmannia valentiana	Eureka
P. davidei sp2	Deroceras reticulatum	San Diego

Project staff originally proposed to import the commercially available Nemaslug® from the United Kingdom into the Biosecurity Level 2 Quarantine Facility at UCR, but with the discovery of three species of Phasmarhabditis in California, project staff focused efforts on culture optimization, life cycle studies, and bacterial identification for future tests.

Project staff isolated forty bacterial species representing one hundred and nineteen single colonies from the nematode collection (Attachment 1) and each was identified by sequencing the 16SrDNA. These bacteria are either maintained on nutrient agar or kept in negative eighty degrees Celsius for long-term storage for infectivity tests.

Nematode choice and no-choice testing (Infectivity and virulence tests): Six representative nematode isolates were tested in a preliminary infection trial in 2014, using non-monoxenic cultures on one to five slug species. Depending on availability, there were two or more individuals inoculated per isolate. Time until slug death varied between nine days to more than two months, suggesting variations in susceptibility of the host and parasitic/pathogenic ability of the nematode and associated bacteria. A. appendiculatum isolate ITD041 successfully caused death of Deroceras laeve eighteen days after inoculation (DAI) and abundant infective stages of the nematode were re-isolated from the cadavers. Further replicated experiments were conducted depending on available test slugs.

Critical to the infectivity tests is the availability of fresh nematode inoculum, and suitable species of disease-free, test slugs. Therefore, prior to inoculum build-up, project staff grew slugs from eggs and studied the life cycle of Phasmarhabditis in culture. At seventeen degrees Celsius, Phasmarhabditis eggs developed to adult egg-laying females in six days. Among the three species, P. davidei had the highest egg-laying capacity, followed by P. californiense, and P hermaphrodita (Table 4). P. davidei is gonochoristic; and while it seems to demonstrate a higher egg-laying potential based on these data, project staff is treating this with caution because this study will need to be repeated in the presence of viable males. Each egg was grown individually to adulthood without a male, and a few developed into dauers or laid a large amount of unfertilized and unviable eggs. Variability among the species can be genetic or attributed to the food source as xenic cultures were used (possibly a mixture of bacterial associate/s). However, this benchmark data allowed to plan succeeding experiments and determine the amount of substrate (slugs) needed for the inoculum build-up using a modified White trap (Wilson, 2012).

Table 4. Life cycle (number of days) of three Phasmarhabditis species associated with invasive slugs in California[1].

Phasmarhabditis spp	Length of cycle (egg egg)	# Eggs/cycle	# Egg-laying days	# days/cycle
Phasmarhabditis californiense (ITD235)	6 days	102 (64-144)	3 (2-4)	29 (24-47)
Phasmarhabditis hermaphrodita (ITD272)	6 days	92 (48-157)	5 (4-6)	13
Phasmarhabditis davidei (ITD510)	6 days	194 (93-252)	3-4	14-15

[1]grown on 1% plain agar at 17C.

As for the test slugs, project staff observed field-collected D. reticulatum to be very susceptible and quite difficult to maintain in confinement in the laboratory or insectary. Thus, attempts were made to grow specimens from eggs to ensure that they would be disease-free. However, they were slow-growing and eventually all cultures collapsed due to an unknown cause. Between the years 2013 to 2014, there was continuous slug collection in the Riverside, California area but most of the animals also died before project team could use them in bioassays. In 2015, there was an increase in the number and survival of slugs that were collected, most of which were Lehmannia valentiana. These were consequently used for the most recent tests.

Phasmarhabditis californiense (ITD235) versus Lehmannia valentiana: This experiment was performed in completely randomized design (CRD), with three treatments (no Infective Juveniles (IJs) =untreated control); double the recommended rate (based on Nemaslug® at 30 IJs/cm2 of soil) of 60 IJs /cm2 soil, and triple rate of 90 IJs /cm2); ten slugs /treatment; in three replicate plates. Inoculum was built up on freshly killed slugs and incubated at seventeen degrees Celsius (Wilson, 2012). Infected Juveniles were collected ten days after inoculation and the nematodes inoculated on the sterile soil surface in assay plates before introducing ten slugs/plate. Mortality was recorded for eighteen days. Surviving slugs were transferred to individual plates and feeding inhibition was determined based on the amount of food (pre-weighed carrot) consumed.

Results showed no significant difference in mortality between the treated and non-treated L. valentiana eighteen days after natural exposure to Phasmarhabditis californiense in assay plates. The carrot discs also absorbed moisture from the paper towel (moistened to maintain humidity in the arena) so it was not possible to determine feeding inhibition using this technique.

Phasmarhabditis hermaphrodita (ITD272) versus Deroceras reticulatum and L. valentiana: In May, 2015 after collecting and maintaining a large number of D. reticulatum, project staff designed an experiment similar to the previous, but with four treatments (no Infective Juveniles (IJs); recommended rate of 30 IJs/cm2 soil, double the recommended rate of 60 IJs /cm2, and a triple rate of 90 IJs /m2). Six D. reticulatum were used and three L. valenteiana slugs /treatment; in three replicate plastic containers. The non-airtight disposable plastic containers were used to ensure better air circulation within the arena. The parameters are mortality and feeding inhibition. Like the previous test, control slugs also died, so the soil substrate was adjusted by reducing the amount of organic matter in the mix. Therefore, for the last experiment, a modification was made.

Virulence tests of six bacterial species versus Lehmannia valentiana: Moraxella osloensis, the bacterial component in Nemaslug® was reported to have caused D reticulatum mortality by itself, after injecting into the shell cavity (Tan and Grewal, 2001). To test the virulence of bacterial associates in the collection, six isolates were selected based on their frequency of recovery (Attachment 1), and/or association with Phasmarhabditis spp. Of the fifteen bacteria associated with Phasmarhabditis, the following were selected: Bacillus pumilus, B. safensis, Ochrobactrum sp., and Alcaligenes faecalis (three isolates). A. faecalis was the most prevalent bacteria among gastropod nematodes and was also associated with all three species. A strain of this bacteria was recently found to cause mortality to Galleria mellonella larva (Quiroz-Castañeda *et al.*, 2015).

Bacteria were enriched in LB, incubated for twenty-four hours at thirty-seven degrees Celsius, and quantified using a spectrophotometer and colony counts from ten-fold serial dilution plates. There were six treatments (bacterial isolates) each receiving four slugs, comparing two methods of inoculation: (a) Feeding method (Wilson and Burch, 2012), using disposable plastic containers with a bran-bacteria mixture (0.4 g:400 µl (~ 10^7 colony forming unit (cfu)) on a weigh boat tucked at the bottom; and (b) Contact method (Tan and Grewal, 2001) in which one hundred microliters (µl) of bacterial inoculum was pipetted onto each slug's mantle. All slugs were inoculated (~ 10^7 cfu) using cell cultures grown to late log phase. Three replicates were provided for each treatment combination.

With the second method of inoculation, the problem was using the right kind of lid to maintain a balance between air circulation in the arena, thus preventing volatile-induced slug mortality and sufficient moisture for slug survival. Unfortunately, the arena was too dry after twelve hours of incubation at seventeen degree Celsius, so in the second experiment, the arena was further modified to maintain this balance. This second experiment has been completed at no cost to this project. This data is being analyzed and will be completed in 2016.

Testing of biological control agent(s) in preliminary trials: Phasmarhabditis hermaphrodita (ITD 290) versus Lehmannia valentiana. This experiment was an improved modification of the infectivity and virulence trial. Furthermore ITD290 is a Lehmannia valentiana isolate, and the highest rate used was five times the recommended (30 IJ/cm2), in a soil mix that was low in organic matter. The autoclaved soil used in the arena is composed of seventy five percent SunGro Sunshine No. 4 mix and twenty-five percent UCR Agricultural

Operations mix. Inoculum was prepared and inoculation was done as previously described. There were three treatments (untreated, 30 IJs/cm^2 and 150 IJs/ cm^2) in three replicates. The target slug species was L. valentiana. Mostly mature specimens were weighed and assigned to different size classes. Similar size classes were assigned to replications, and experimental units were randomized among treatments. Five slugs were provided per treatment. Mortality was noted in addition to feeding inhibition. This study is on-going at no cost to the project. The results showed the maximum mortality rate achieved for Lehmannia valentiana exposed to Phasmarhabditis hermaphrodia did not increase beyond 60% for the highest inoculation rate. Furthermore, project staff did not observe any mortality in the lower inoculation rate and control bioassays but the slugs did continue to show mild symptoms of infection for the lower rate.

Three days after exposure, L. valentiana at the higher rate of 150 IJ/cm^2 exhibited swelling of the mantle that progressed to constriction of the area behind the mantle, exposure of the shell cavity, extrusion of the vestigial shell, and rupture of the integument. At five days after exposure, slugs were dead or in varying degrees of symptom development with hundreds of nematodes swarming either in the “pool” of the shell cavity or over the cadaver (Figure 4). At nine days after exposure, mortality was noted only at the higher rate of 150 IJ/cm^2 (Figure 4), however, at the lower recommended rate of 30 IJ/cm^2 the slugs also showed milder symptoms of infection.

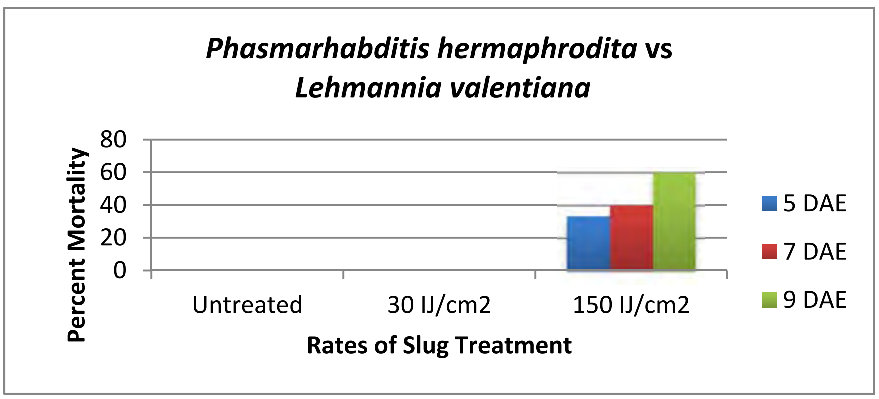


Figure 4. Percent mortality of Lehmannia valentiana exposed to 30 IJ and 150 IJ of Phasmarhabditis hermaphrodita per cm^2 compared with untreated control over time. DAE=Days after exposure

Testing of biological control agent(s) under controlled field conditions in a specialty crop: Given the difficulties and delays project team has experienced with importing arthropod natural enemies from Europe and other parts of the US, and the sheer number of nematodes that were recovered from California gastropods, including two species new to science, it was not possible to test the biological control potential of the most promising nematode species under controlled field conditions in a specialty crop. UCR was awarded a 2015 Specialty Crop Block Grant Program grant to conduct such research with the ultimate aim of developing an agent for widespread use in California nurseries.

A workshop for stakeholders in the nursery industry in California was held on June 23, 2015 at the University of California, South Coast Research and Extension Center in Irvine, California. The goal of the work shop was to educate attendees on how to identify different species of snails and slugs, where to find gastropods in nurseries, and how best to manage snails and slugs in nursery plants. Project staff also delivered information on the discovery of the nematode, Phasmarhabditis hermaphrodita, and the implications of the discovery for snail and slug management in California nurseries.

No commodities other than specialty crops benefitted from this research. The target for this project was horticulture and nursery crops, including floriculture, and funds were used to solely to enhance the competitiveness of specialty crops. Snails and slugs for natural enemy screening and colony establishment were only collected in nurseries and garden centers throughout California. Also, only stakeholders in the Californian nursery industry were asked to participate in the survey questionnaire. All supplies and equipment purchased using this project funds were used solely for this project. In addition, when these supplies when not in use, they were stored in a designated project cabinet in the laboratory of the Project Director. Only project team members had an access key for this cabinet. Only stakeholders in the California nursery industry attended the information dissemination workshop.

There are no official project partners listed on this project. However, a number of scientists assisted during the course of this research at no additional cost to the project:

- The Area Integrated Pest Management Advisor for San Diego, Orange and Los Angeles Counties assisted the Assistant Research Specialist and the Project Director with the survey questionnaire, the project website and with organizing the information dissemination workshop at the end of the project.
- A Professor from National University of Ireland, Galway and Professor from Alejandro Tena, Instituto Valenciano de Investigaciones Agrarias Valencia, Spain provided fieldwork support and laboratory space for the Assistant Research Specialist during natural enemy collection in Ireland and Spain.
- A National Malacologist from USDA-APHIS-PPQ and a Research Scientist from USDA-APHIS-CPHST confirmed the identification of Boettgerilla pallens, discovered for the first time in the U.S. during the gastropod surveys.
- A USDA researcher assisted the Assistant Specialist with parasitoid collecting in Indiana and Illinois states.
- A professor from the Department of Plant Pathology and Microbiology, UC Riverside collaborated with the team on the bacterial component of the research. She also contributed towards bacterial sequencing costs. One of her PhD graduate students was mentored in the De Ley lab and was trained on bacterial identification, maintenance of cultures and long term storage and molecular diagnostics. She is currently preparing a manuscript on the culture-dependent bacterial associates of gastropod nematodes and will continue her research on microbiome of slugs.

Goals and Outcomes Achieved

Goal one was to increase the number of nursery owners and home horticulturalists who would utilize biological control as a management strategy for nursery plants. This outcome was quantified in the form of a questionnaire issued to stakeholders at the onset of the research, at the end of the project, and within five years of project implementation. The survey questionnaire (http://ucanr.edu/survey/survey.cfm?surveynumber=9511) was designed by the Assistant Specialist and Project Director with assistance from UC Cooperative Extension. In the early stages of the project, the questionnaire was completed by a total of two-hundred and four stakeholders online, at the Slugs and Snails: Biology and Control Meeting in San Marcos, California in March, 2013; at Best Management Practices Programs for California Nurseries: Review and Outlook Meeting in Salinas, California in May, 2013; at the

California Nursery Conference in Etiwanda, California in October, 2013; and at the 2013 Nursery/Floriculture Insect Symposium in Watsonville, California in December, 2013.

To encourage online participation, details of and a direct link to the survey were posted on the Facebook page of the San Diego County Flower and Plant Association (https://www.facebook.com/SDCFPA?ref=stream) and stakeholders were also able to access the survey through the project website.
In terms of stakeholder knowledge, an average of 72% of participants correctly identified three snail taxa (Brown Garden Snail, Decollate Snail and Amber Snail) whereas 24.3% of participants correctly identified three slug species (Grey Garden Slug, Cellar Slug and Valencia Slug). This result is significant when considering that slugs appear to be the most significant gastropod pest in the nursery industry in California, and it highlights the need for stakeholder training in slug identification. In terms of management, 66% of survey participants would use a biological control agent of invasive snails and slugs and an additional 24% would probably try it but would wait until others tried it first. Interestingly, if the agent was more expensive than molluscicides but provided more sustainable control than current control measures, 58% of participants would use biological control and an additional 25% would wait until others tried it first. Twenty six percent of participants stated that gastropods were in the top three pests of their production system, 44% said snails and slugs were in the top five pests of their systems and 78% considered them to be in the top ten pests. In terms of current control costs, 25%, 22% and 27% of surveyed growers spend over $10 per acre per year, $11-$99 per acre per year and $100-$499 per acre per year, respectively, on molluscicides only, while 5% of stakeholders spend over $5,000 per acre per year. In terms of total cost excluding molluscicides (e.g. costs of permits and crop destruction), 32%, 22% and 20% of participants spend $1-$100 per acre per year, $101-$499 per acre per year and $500 – $999 per acre per year respectively while 5% of stakeholders spend >$20,000 per acre per year controlling these pests.

A follow-up survey of twenty-seven stakeholders was completed during the information dissemination workshop which was held at the end of the project in 2015. During this survey, 100% of stakeholders answered that they would use a biological control agent of snails and slugs if it was available, even if the agent was more expensive than current control measures. This highlights the strong stakeholder demand and interest in a nematode biological control agent of these pests.

Goal two was to increase end-user knowledge of gastropod pests and their management in nursery plants in California. This performance measure was quantified using the number of visitors to a project website. The latter was designed by the Assistant Specialist with assistance from UCANR Communication Services and Information Technology. The website (http://ucanr.edu/sites/CalSnailsandSlugs/) was launched September 20, 2013. It provides information on the most damaging species of snails and slugs in California nurseries, detailed information on management strategies, a link to our grower survey, and information on useful publications and websites. The aim of the site is to increase end-user knowledge of gastropod pests and their management in nursery plants in California. The website has also been registered on Google Analytics which allows to gather information on the number of visitors to the site, their location in the world, and time spent on the various pages.

According to Google Analytics, in the twenty-three months since its launch, the website has been visited a total of 5,987 times with a total of 10,748 page views. Of these visits, 5,421 were new users with the remaining 566 representing return visitors. Sixty one percent of all visits to the website originated in the US with California being the best represented (50.3%) state followed by Texas (3.6%), New York (3.1%), Florida

(2.5%) and Virginia (2.2%). Furthermore, the website has received visitors from all 48 U.S. States and Washington DC, indicating the importance of our website for stakeholders on a national scale. In California, the cities where the website was accessed most often are Los Angeles (11.0%), San Francisco (7.0%), San Diego (6.8%), Riverside (3.9%), and Sacramento (3.4%). These five cities make up 32.1% of the traffic flow to the site. The website also recorded visitors from 107 countries including China, Japan, Canada, United Kingdom, Germany, India, Russia and South Korea. The five most popular pages (other than the home page) were California's Pest Snails and Slugs; Management using Natural Enemies; the Brown Garden Snail (Cornu aspersum); the Garden Slug (Arion hortensis) and the Cellar Glass Snail (Oxychilus cellarius).

The long term goal for the outcome measures is to ensure a biological control adoption rate of 20% five years after an agent becomes available. Given that project staff has demonstrated an increase in stakeholder demand for biological control since the start of the project, and that stakeholder willingness to use biological control was measured at 100% in a recent survey, project staff is confident that this adoption rate will be met.

Expected measurable outcome one was to increase the number of nursery owners and home horticulturalists who would utilize biological control as a management strategy for snails and slugs infesting nursery plants, and the goal was successfully achieved. At the onset of the project, 58% of participants said they would use biological control, and at the end of the project, one-hundred percent of surveyed stakeholders answered that they would try biological control even if others had not tried it first and if it was more expensive than current control measures.

Expected measurable outcome two was to increase end-user knowledge of gastropod pests and their management in nursery plants in California. The target for this performance measure were set at one-hundred visitors to the project website for year one; five-hundred visitors for year two, and one thousand visitors for year three. In the twenty three months since its launch, the website has been visited a total of 5,987 times, and consequently, project team have met and exceeded these target goals.

There have been a number of successful outcomes of this project: Project staff successfully showed that invasive slugs (79% of total catch) and not invasive snails (21% of total catch) are more abundant in nursery plants, and consequently are likely to be a more important pest. The two most abundant species were the European invasive slugs, Deroceras reticulatum and Lehmannia valentiana, and they accounted for almost 50% of the total gastropod catch. Project staff have also heightened awareness that slugs and not snails are more damaging to nursery plants through presentations at meetings and workshops. Another successful outcome was the discovery of the invasive slug Boettgerilla pallens for the first time in the US. Project team collected specimens in San Mateo County and Humboldt County in northern California.

Furthermore, using a survey questionnaire, project staff demonstrated the urgent need for alternative control tactics to help manage snails and slugs in California nurseries, and were able to identify strong stakeholder demand for the development of a biological control agent. Identification of the inability of most nursery growers to correctly identify damaging slug pests of nursery crops which consequently influences their ability to select the best strategy for control. Development and maintenance of a website on the snails and slugs of California nurseries which has been visited over five thousand times. Discovery of the malacopathogenic nematode, Phasmarhabditis hermaphrodita, for the first time in the US. This nematode is being used as an effective biological control in Europe and has major potential for use as a biological control agent in California. Demonstration in laboratory biological control tests that the US strain of Phasmarhabditis hermaphrodita is lethal to the invasive slug, L. valentiana. The latter is one of the primary slug pests infesting nurseries in California. Additionally, project staff published two international-peer reviewed papers and delivered seven oral presentations during the course of this project.

Beneficiaries

There were many beneficiaries of this project including commercial producers such as wholesale nurseries, non-commercial producers such as home horticulturalists, California Pest Control Advisors, University of California Cooperative Extension, County Agricultural Commissioner employees, and societies concerned with nursery production, such as San Diego County Flower and Plant Association.

According to the 2012 Census of Agriculture, there were 9,545 farms totaling over 75,000 acres specializing in nursery and greenhouse specialty crops in California. Furthermore, home horticulture is the most popular hobby in the US and most of the 38.8 million people in California practice some form of horticulture. This project has had a direct positive impact on both of these stakeholder groups by increasing the awareness of damaging, invasive snails and slugs in nursery and greenhouse plants, and providing information on how to effectively manage these pests. Furthermore, by identifying three potential nematode biological control agents (P. hermaphrodita and two new species of Phasmarhabdits) this project has laid a solid foundation to develop an agent for widespread use against snails and slugs in California nurseries. The potential economic benefit of such an agent can be estimated as follows: During 2012 year, the value of the nursery industry in California was $3.54 billion. The reported mean efficacy of the nematode P. hermaphrodita as a biological control agent against gastropod damage to nursery plants in Europe was estimated at 72.4% (Rae et al., 2007). Assume a conservative five percent loss in California's nursery industry to gastropods due to direct feeding on plants, reduced quality rating due to mucus/faeces, inspections, permits, shipment destruction due to quarantine species, the potential gain to the industry by using biological control (based on P. hermaphrodita) would be around $128 million annually.

Lessons Learned

Project staff learned there is a large stakeholder demand for the development of a biological control agent of snails and slugs in California, and stakeholders were very keen to assist with this research, such as survey participation and access to nurseries for gastropod collections. There were also significantly more visitors to the project website than anticipated, 5,987 visitors compared to the established goal of 1,000 visitors; this indicated the importance of such a resource for stakeholders in the industry. Furthermore, there is a diverse fauna of nematodes associated with pest snails and slugs in California nurseries, and some of these nematodes in combination with their bacterial associates are lethal to key gastropod pests, which highlights their biological control potential.

Another lesson learned throughout the duration of this project was the issue with importing snail and slug parasitoids under permit from Ireland and Spain; this proved to be exceedingly difficult. In the future, project staff will collect parasitoids in areas such as France, where courier and/or freight companies regularly ship living insects to California. Another lesson learned was that it was difficult to establish robust colonies of certain slug species e.g. Deroceras reticulatum for biological control testing. In an effort to mitigate this problem, project staff mass collected these species in the field and confined them in containers in the laboratory for two weeks prior to testing to ensure that they would be parasite free. This approach, however, also proved problematic with large mortality rates within two weeks of the field collections. Future attempts at rearing these species will utilize sterilized containers, a variety of organic vegetables, higher humidity in colony cages, and lower rearing temperatures.

Some unexpected outcomes of implementing this project was the discovery that slugs, and not snails were more abundant in California nurseries; and consequently, are likely to be more of a pest than invasive snails in these production systems. Also, many stakeholders in the industry were unable to correctly identify three slug species commonly encountered in nursery plants. Collecting the European invasive slug, B. pallens in California nurseries that were the first recorded in the U.S. was an unexpected discovery during this course of the project. Also, finding a diverse fauna of nematodes associated with invasive gastropods in California nurseries, and discovering two species of nematodes new to science was unexpected.

Additional Information

Attachment 1 includes the list of bacteria associated with gastropod nematodes in culture.

The Associate Specialist delivered the following conference presentation during the course of this project:

Tandingan De Ley, I., Mc Donnell, R.J., Alvarado, S., Jackson, D., Aronson, E., Wilen, C., Paine, T., and De Ley, P. (2015) Discovery of multiple Phasmarhabditis spp. in North America and their potential for biocontrol of invasive gastropods. 47th Annual Meeting of the Organization of Nematologists of Tropical America (ONTA), Varadero, Cuba, May 17-22, 2015

She also presented the following 3 talks as an invited speaker at no cost to the project:
Tandingan De Ley, I., Mc Donnell, R.J., Paine, T., and De Ley, P. (2015) Phasmarhabditis spp. in North America and implications for biocontrol of invasive gastropods. 46th Anniversary and Annual Scientific

Conference of the Pest Management Council of the Philippines, Davao City, Philippines, May 5-8, 2015

Tandingan De Ley, I. (2014) Finding the nematode in a haystack: Phasmarhabditis lives in North America. Department of Nematology Seminar at UC Riverside, December 10, 2014

The Assistant Specialist delivered the following presentations as an invited speaker and at no cost to the project:

Mc Donnell, R.J. and Paine, T.D. (2014) Pest snails and slugs in California. California Pest Control Advisors Ventura Meeting, Santa Paula Community Center, Santa Paula, California, 10th September 2014

Mc Donnell, R.J. and Paine, T.D. (2014) California's invasive slugs, future threats and some novel approaches for their control. Quarterly Meeting of the Southern California Entomology Association, Los Angeles Country Arboretum and Botanic Gardens, Arcadia, California, 4th March 2014

Mc Donnell, R.J. (2013) West coast slugs: faunal composition, diagnostic characters and future threats. National Plant Diagnostic Network Workshop on Invasive Slugs and Snails, University of California, Davis, 26th-28th March 2013

Mc Donnell, R.J. and Paine, T.D. (2013) European Invaders: California's Invasive Snails and Slugs and a Novel Approach to their Control. Slugs and Snails in Agriculture, Production Nurseries, and Landscapes: Biology and Control, San Marcos, California, 13th March 2013

Publications:
Two international peer-reviewed papers have already been published using data collected during this project. The peer reviewed papers can be found in the journal of Nematology at brill.com/nemy and the full references to these journals are provided below:

Tandingan De Ley, I., Mc Donnell, R.J., Lopez, S., Paine, T. and De Ley, P. (2014) First record of Phasmarhabditis hermaphrodita (Nematoda: Rhabditidae), a potential biocontrol agent isolated for the first time from invasive slugs in North America. Nematology 16: 1129 – 1138.

Mc Donnell, R.J., Robinson, D.G., Barr, N., Tandingan De Ley, I., De Ley, P. and Paine, T.D. (2014) First report of the invasive slug Boettgerilla pallens Simroth, 1912 (Boettgerillidae) in the US. American Malacological Bulletin **32:** 209-210.

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Mc Donnell, R., Robinson, D.G., Barr, N., Tandingan De Ley, I., De Ley, P. & Paine, T. (2014). First report of the invasive slug Boettgerilla pallens Simroth, 1912 (Boettgerillidae) in the United States. American Malacological Bulletin 32, 209-210.
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Tandingan De Ley, I., McDonnell, R., Lopez, S., Paine, T.D., & De Ley, P. 2014. Phasmarhabditis hermaphrodita (Nematoda: Rhabditidae), a potential biocontrol agent isolated for the first time from invasive slugs in North America. Nematology 16, 1129-1138.

Wilson, M.J. (2012). Pathogens and parasites of terrestrial molluscs. In: Lacey, L.A. ed. Manual of techniques in invertebrate pathology, 2nd ed. San Diego, USA: Academic Press, pp 429-441.

Wilson, M. & Burch, G. (2012). An improved bioassay for screening bacteria for biocontrol activity against slugs that avoids volatile-induced slug mortality. Biocontrol Science and Technology 22,1235-1237

California Department of Food & Agriculture
Specialty Crop Block Grant Program
Final Performance Report

USDA Project No.: 60	Project Title: Host Range Testing of the Olive Psylla Parasitoid	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12060	**Date Submitted:** December 2015
Recipient Contact: Charles H. Pickett	**Telephone:** 916-262-2053	**Email:** cpickett@cdfa.ca.gov

Project Summary

Olive psyllid was first reported in California in 2007. It attacks only olive trees and was found at multiple sites in San Diego and Orange counties. It has since spread to Riverside and Los Angeles Counties. Based on the history of its distribution in southern Europe, this pest has the potential to spread throughout most of the state's olive growing regions. The psyllid attacks flower buds and has been reported reducing up to 60% of olive yields in the western Mediterranean. As part of foreign exploration efforts for other pests invasive to California, Psyllaephagus euphyllurae (Encyrtidae), a stingless wasp, was found attacking the olive psyllid in eastern Spain, a region home to the olive psyllid. The focus of this project is to conduct host specificity tests needed to obtain a permit to release this parasitoid into commercial olive trees. The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) requires that the candidate parasitoid has a limited ability to attack or reproduce on insects other than the target pest. These tests determine the preferred host or food for this parasitic wasp. Since olive psyllid attacks flower buds, permanent populations of this new natural enemy have the potential to permanently reduce numbers of this olive pest and increase yields.

The natural distribution of this olive pest is the western half of the Mediterranean Basin, including Spain, France and Tunisia, where it has been reported feeding on olive trees. Although project staff do not know for certain that it will become a serious pest in commercial production regions of California, it is known that the psyllid is spreading and that it lacks specific natural enemies to control its populations. The olive psyllid is reproductively active during spring months when nymphal (immature stages) populations can cause significant reductions to the olive fruit set. This project had two main objectives: (1) conduct host specificity tests and obtain a field release permit; and (2) to rear and release this parasitoid into multiple locations. By obtaining a field release permit sooner than later, P. euphyllurae could be released and permanent populations established in southern California. The impact of this parasitoid on populations of olive psyllid could greatly impair further northern movement.

The olive psyllid feeds almost entirely on olive trees and is reproductively active during spring months when trees are flowering, as well as during late winter. The feeding by adults and nymphs damages flower blossoms, and as a result, has a direct and major impact on fruit yield. Yield losses of up to 60% have been reported from some countries in the western Mediterranean. All commercial olive acreage could be affected by this pest. From 2008 to 2012 in California, olive acreage increased by 46% and production by 140%. These figures are expected to increase as the demand for United States olive oil increases, and methods for mechanization are adopted. Driving the demand for olive fruit are the health benefits of table olives and oil, and heightened interest in their culinary attributes. Currently less than 5% of olive oil sold in California is grown in this state, with the remainder being imported from Europe. With its ideal climate and soils, California is poised to exploit this demand. Furthermore, olives are one of the few crops that can survive and produce on low amounts of water, a new factor entering the horticultural arena. Olive trees represent an

excellent choice to replace more water demanding crops. Because olive trees are widespread in urban centers due to their aesthetic and ornamental value, olive psyllid populations can thrive outside of commercial olive regions regardless of insecticide or trapping management systems. The introduction and permanent establishment of P. euphyllurae will affect populations of this pest in all areas, reducing industry costs, and public exposure to pesticides. The control provided by this parasitoid will be free of any additional costs beyond host testing and its release, and continue into perpetuity. Its release into olive production areas is only limited by a field release permit.

This project did not built on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Collections:

Initially, the parasitoid under study P. euphyllurae was to be cultured at University of California (UC), Berkeley. However due to the difficulty in rearing enough individuals for the tests, a decision was made to use field collections instead. The parasitoid appears to produce one to two generations a year, passing most of the year in a resting state. Collections for host specificity testing were conducted spring of 2013, 2014, and 2015. To provide the dozens of adult parasitoids needed for these studies, collection trips to southern Europe were made over these years. Trips were made to eastern Spain and collections were made from three provinces along the western shores of the Mediterranean Sea: Catalonia, Valencia, and Murcia. Based on previous trips by the senior investigator, it is known that these areas have relatively high populations of olive psyllid. Samples were taken from abandoned olive orchards and with help from a local cooperator, from organically produced commercial trees. The 'mummy' state of parasitized psyllids was collected (dead psyllid with developing parasitoid inside body). Typically an adult parasitoid emerged from this stage within three weeks of collection. With each passing year, sites with the best returns were revisited subsequent years. As a result, higher numbers of parasitoids were collected each year, from 227 adult P. euphyllurae in 2013 to 356 in year 2015. The total number of mummies collected, however, was much higher since a second species of Psyllaephagus was discovered (but in lower numbers) and two species of hyperparasitoids. Total number of mummies increased from 376 in 2013 to 805 in year 2015. A scientific paper has recently been published on these species and the presence of unreported male P. euphyllurae (only adult females had been found). Another paper is in production on the finding of a second species of Psyllaephagus attacking olive psyllid.

Tests:

Over the last two and a half years P. euphyllurae has been exposed to four non-target psyllids to determine its specificity towards the olive psyllid. The question was will it attack species of psyllids other than the olive psyllid, and if so to what degree. The species of psyllids chosen for the tests were based on insect availability and on habitat proximity to olive trees grown in California. Two species are native to California, and one is a weed biocontrol agent under study by the USDA Agricultural Research Service (ARS). Five treatments have been used to measure host specificity: Two sequential, no-choice tests; two static, no-choice tests (short and long-term), and a static, short term choice test. Psyllaephagus euphyllurae demonstrated a high degree of host specificity throughout these tests. The parasitoid was unable to develop into an adult on any of the non-target psyllids to which it was exposed. Psyllaephagus euphyllurae only developed from olive psyllid hosts across the 101 replications representing five different experimental conditions. Parasitism under test conditions using naïve females was relatively low 17.4%, however host feeding (adult wasps feed directly on olive psyllid nymphs) was exceptionally high. Mortality of olive psyllid due to factors other than parasitism in test cages was 74.1% while in controls (no exposure to parasitoid) was 22.4%. Other recent studies involving different species of psyllid parasitoids, suggests that host feeding prior to initial oviposition greatly increases reproductive output, i.e. number of attacked psyllids. Under natural, field conditions parasitism would most likely be much higher than measured in our studies, and host feeding lower.

Using results from host specificity testing, a petition for a field release permit was prepared for the USDA APHIS and submitted in November, 2014.

Survey:
Survey work in southern California in 2014 and 2015 year showed that the olive psyllid continues to spread since it was found at additional locations not reported previously by others. Fifty-seven sites were surveyed in 2015. Of these, psyllids have been found at 23 either in 2015 or in previous years. This represents 5 more sites found with psyllid populations than found in 2014 or earlier. Of the twenty-three sites where psyllids have been found in the past, 4 did not have any this last year, most likely due to insecticide control measures. The survey also showed that the olive psyllid population is free of parasitism by any native parasitoids. This is not surprising since most species of psyllids are relatively plant specific, and the parasitoids that attack them are specific to their habitat and the psyllids on which they reproduce. Possible generalist predators include a predacious bug *Anthocoris* sp., lacewing *Chrysoperla* sp., and spiders (Araneae). None of the 1,058 collected nymphs showed any signs of parasitism, which agrees with earlier surveys by UC Riverside researcher. The generalist predators are not expected to have a major impact on the olive psyllid population since they tend to be opportunists. Sites suitable for releases of P. euphyllurae were identified in Riverside and San Diego counties.

This project benefitted only California specialty crops.

The project partner UC Riverside researcher conducted studies to improve rearing and survivorship of parasitoids. Psyllaephagus euphyllurae is difficult to rear in part because it needs to host-feed (predation on olive psyllid nymphs) before ovipositioning (laying eggs into its prey the olive psyllid). Studies were conducted to determine if there are any alternate foods that can be provided to deter this habit, since it requires many more psyllids to produce new parasitoids. Mixtures of honey plus pollen provided no additional benefit. Two sizes of cages were tested, with the smaller cage (ca. 0.5 gallon) providing better results. Findings from these studies will make it easier to maintain laboratory cultures of this wasp.

Goals and Outcomes Achieved

Several collection trips were made to southern Europe, France to provide parasitoids for the host specificity tests. Collected insects were processed and packaged at the USDA ARS European Biological Control Laboratory in southern France, prior to hand carrying them back to California. Appropriate permits were obtained from France, the USDA APHIS and California Department of Food and Agriculture (CDFA) prior to each collection. All trips were successful in meeting the numbers of adults needed for the host specificity tests at UC Riverside. Host testing was completed in a quarantine facility at UC Riverside, with tests conducted spring of each of the last three years. Results from these studies provided proof that the candidate parasitoid P. euphyllurae has a very limited host range, i.e. it prefers to reproduce exclusively or almost entirely on the olive psyllid. In order to conduct these tests, several cultures of native and exotic psyllids were maintained, and native and exotic species of plants were grown in large quantities at CDFA in Sacramento and at UC Riverside. Several species of plants and insects had to be available at the same point in time in order to successfully carry out these host choice tests.

A petition for a field release permit was completed fall 2014 and submitted to the USDA APHIS for review. As of December 2015, project staff is still waiting on the outcome of this review. The final step in this project is to make releases of the adult wasp into olive trees in either southern California or more northern locations if populations in these regions should arise. Because the field release permit was not provided before June 2015, the final and last objective of the grant remains unfulfilled.

The long term goal for this project was to release P. euphyllurae into California by obtaining the field release permit. If the permit had been granted by June of this year, this objective would have been met.

The most successful outcome of this project is completion of testing needed to provide enough data to warrant a request for a field release permit. The coordination needed to bring together the plants and insects required for these tests was demanding. Five different types of preference tests were conducted on four non-target psyllids. In all, no successful reproduction was recorded over 101 replications representing these five tests.

Beneficiaries

The main beneficiary of this work is the olive industry, both table olives and oil. Until the candidate parasitoid is released, actual benefits by these industries cannot be realized. Both organic and conventional producers will gain from permanent establishment of P. euphyllurae in California. Its net impact will be an increase in yield and reduction in pesticide usage, given an expanding psyllid population. The olive psyllid is spreading throughout southern California, and has the potential to spread northward both along the coast and inland where commercial olives are produced. It attacks all olive trees regardless of how the olives are marketed. The most recent estimate for value of all olive trees grown in California is $134,888,000 coming from 40,000 acres of reported production. The psyllid feeds directly on the flowers of olives, thus has a direct impact on yield. One study reported from Tunisia found a 60% reduction in yield if the pest population was left untreated. This may not reflect an average value throughout the Mediterranean region; and misuse of pesticides, effectively eliminating the role of parasitoids, likely aggravates the problem. Nevertheless, the psyllids feeding does directly impact yield and will force growers to increase their pesticide usage in order to maintain optimal yields. The profit margin for both table and oil olives is small, so any increase in production costs will have a major impact on these industries. The olive oil industry is just starting to take off in California. With 95% of oil consumed in the United States coming from out of country, the market for expansion in California (which produces almost all the olive products in the country) is huge. By being proactive and getting a highly specialized parasitoid established in southern California (limited commercial acreage), could stall this pests spread northward and eliminate the need for additional control costs. If no action was taken on introducing a highly specialized natural enemy of the olive psyllid into California, there would be a serious time lag from initiating safety studies to getting the parasitoid released in the state.

Lessons Learned

One of the greatest hurdles of this project was the availability of trained staff. The first person hired to help conduct studies left the project half way through the first year. The assistant to this individual, a recent graduate of UC Riverside, had to learn on the job all the tasks needed to carry out studies. The principle investigator is located in Sacramento. Despite this set-back, the primary goals of the project were fulfilled, i.e. data needed to justify a field release permit for the olive psyllid parasitoid.

New species of natural enemies associated with the olive psyllid were discovered during this project. This was only possible because of the presence of highly skilled systematists associated with the UC Riverside quarantine facility who helped with the initial identification of collected insects. Other unexpected outcomes from the results concern the biology of the candidate parasitoid, P. euphyllurae. This parasitoid, like its host the olive psyllid, pass most of the year in a resting state, i.e. they stop developing for over six months of the year. This helps to explain how they both survive the dry, hot summers of eastern Spain.

The goal not achieved is the release of the biocontrol agent, P. euphyllurae. The only remedy would be to allow for even greater time for the approval process to obtain field release permit, something completely out of control. It may have been possible to complete the lab tests sooner, if not for the loss of a key staff member during the first year of this study and a better understanding of the candidate parasitoid's biology.

Additional Information

Publication:

Triapitsyn, S. V., J. M. L. Jones, C. H. Pickett, M. L. Buffington, P. F. Rugman-Jones, and K. M. Daane. 2014. Description of the male of Psyllaephagus euphyllurae (Masi) (Hymenoptera, Encyrtidae), a parasitoid of the olive psylla, Euphyllura olivina (Costa) (Hemiptera, Liviidae), with notes on its reproductive traits and hyperparasitoids. Journal of Entomological and Acarological Research, 46: 112-118.

USDA Project No.: 61	Project Title: Rapid, non-invasive, and early warning detection of mycotoxigenic aspergilli on almonds and pistachios in holding, storage, and transit using hand portable gas chromatography-mass spectrometry	
Grant Recipient: United States Department of Agriculture, Agricultural Research Service (USDA-ARS)	**Grant Agreement No.:** SCB12061	**Date Submitted:** December 2015
Recipient Contact: John J. Beck	**Telephone:** (510) 559-6154	**Email:** john.beck@ars.usda.gov

Project Summary

The project was designed to address the problem of aflatoxin contamination of almonds and pistachios, which results in millions of dollars of lost product annually. Aflatoxins are metabolites produced by *Aspergillus flavus* and *A. parasiticus*, ubiquitous fungi of California tree nut orchards, and represent a grave food safety problem due to their carcinogenic attributes. Current methods of analysis involve removal and destruction of twenty kilograms of product, utilize laboratory-based methods (e.g. High Performance Liquid Chromatography), are expensive, and can take weeks for results. Because aflatoxin contamination can be limited to one or two highly contaminated nuts, current methods do not guarantee detection of the infected nuts, thus posing serious health and safety concerns to the public.

Despite an increase in self-regulation and aflatoxin testing protocols by the almond and pistachio industry, the costly rejection of exported product continues. A reliable, early warning detector of aflatoxin contamination has been cited as a critical need of the industry. The current project has the strong support of both the Almond Board of California and the California Pistachio Research Board of California.

This project does not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Torion Technologies (now part of PerkinElmer, Inc.) was the contracting company responsible for the design and development of the needed hardware and software modifications of the portable Gas Chromatography-Mass Spectrometry (GC-MS) and its application toward the goals of the project. The major highlights of the activities performed include: Development of a new needle trap optimized for this project's intents; Development of a reliable sample injection method for injecting samples from the developed needle trap into the portable GC-MS instrument and for existing benchtop GC-MS instruments; Development of a ruggedized needle trap holder for field sampling with the developed needle trap; Trap holder for use in laboratory and typical field conditions; Trap holder (probe) for insertion into almond stockpiles or pistachio silo containers; Design and prototype development of a portable pump capable of precise air flows under varying field/sampling conditions for collection of volatiles onto developed needle trap assemblies.

Agricultural Research Service (ARS) PI's laboratory and associated personnel were responsible for identifying signature volatiles (biomarkers) that signified fungal contamination in almond and pistachio kernels; identifying abiotic and biotic conditions that biomarker volatiles are produced; testing portable GC-MS hardware and software prototypes; loading identified biomarkers fragmentation patterns and retention times into portable GC-MS database. The major highlights of the activities performed included:

Determined that fungal spores transitioning from resting to germination release a suite of volatiles. Agriculture Research Services scientists discovered that key biomarker volatiles are among the odors released. It was determined the biotic and abiotic conditions that the fungal spores produce the volatiles. Environmental conditions include:
Relative humidity--which is important for stored volatiles, moisture plays a big role in potential fungal growth, temperature, host plant tissue–different hosts for the fungi (pistachio or almond kernels, shell, hull) may produce different volatile profiles.

Agriculture Research Services scientists also discovered how kernels may be contaminated despite no visible damage to kernels. This was a recent, but very critical finding for this study, and will help the almond and pistachio industry become aware of possible vulnerable stages of processing. Scientists used the detector to locate indistinguishable contaminated kernels based on volatile emissions.

The project did not benefit any commodity other than the intended pistachios and almonds, which are California specialty crops. In a much broader sense, once this needed technology is fully developed and more widely available, it can be applicable to many other crops across the nation and perhaps even international. However, this will not be fully realized until research such as this adds to the general knowledge of portable and real-time detection of toxigenic and/or pathogenic microbes in food products. Project staff focused efforts on the immediate problem of pistachio and almond fungal contamination and the associated volatiles relating to fungi on these food products.

Torion Technologies (now part of PerkinElmer, Inc.) provided cutting edge research and development of inlet, injector, needle trap, needle trap collection devices, and portable volatile collection pump systems for existing Tridion-9 portable GC-MS system.

Paramount Farms and Paramount Farming Companies (now Wonderful Orchards Company) provided pistachio and almond materials for mimicking stored product conditions, which were made available with on-site access for field testing of the portable GC-MS. This access remains intact after the grant period for continued studies.

Goals and Outcomes Achieved

Measurable outcomes for determining parameters for field-realistic conditions were achieved: Changes in volatile emissions from the naturally contaminated tree nuts as a result of changes in relative humidity levels demonstrated that fungal metabolism fluctuates as a result water activity and relative humidity. It has been known that aflatoxin growth requires certain water activities. This result confirmed that fungal volatile emissions from tree nuts could be used to monitor fungal growth; thus, providing an early warning signal. A definitive measurement of actual contamination (amount of fungal growth, fungal spores, or aflatoxin) has not yet been realized. However, a breakthrough experiment has possibly provided evidence for a point of contamination into almonds during storage. Some details of the preliminary results are provided below.

The working prototype of the GC-MS instrument was to have undergone field trials by the end of the grant funding period. This final result was not obtained during the life of the grant. ARS researchers have completed data analysis of the almond experiments of complementary in-laboratory experimentation and will apply these findings to ongoing laboratory-based blind studies and to the in-field trials of the 2015 crop stockpiled almonds.

Final testing of hardware is still in the pre-completion stage; some calibration experiments have been concluded. Lab-based experiments are still in process. In-field analyses with portable GC-MS will be completed prior to next growing season, which is the 2015 winter months. Planned goals for this project were to complete the final testing of the hardware under field conditions. The instrument was tested on a different system to determine if the sensitivity was sufficient to discriminate damaged plant volatiles and non-damaged volatile profiles. Working with newly designed and manufactured prototypes led to unavoidable and unanticipated delays while trouble-shooting and diagnostic evaluations were performed on the instrument. Also, the ARS laboratory is still awaiting the pump that will allow the collection of volatiles via the newly designed probe. Inoculation of kernels and subsequent analyses of volatiles was planned; however, a discovery in the ARS laboratories provided insight into a key point of contamination. Project team will follow up on the lead after this project is concluded.

For the GC-MS instrument-- design, development, prototype testing, and subsequent re-designs of the inlet, injector port, needle trap and associated assemblies; and stockpile and storage container probe for needle trap were fully realized and adapted for the portable GC-MS. The full realization of the re-designed and developed pump is pending and should arrive in the ARS in January or February of 2016. The Torion scientists are completing software testing of the pump. Agriculture Research Services scientists will incorporate this pump into their in-laboratory and in-field analyses.

For the contaminated tree-nut emission profiles, biomarkers have been identified for contaminated kernels. Further analysis of data from pistachios is ongoing and should provide potential biomarkers to use for signaling of contamination. Experimentation on pistachios provided some needed insight into how and when the pistachios are contaminated. These results will help guide the ARS scientists with ongoing experiments. The ARS scientists are committed to completing the goals of the project using ARS time and resources after this grant is over.

A portable GC-MS system with newly designed and installed injector/needle trap/pump system was developed and tested on mimicked storage/stockpile conditions; and the identify of biomarker volatiles that can be detected using the developed portable GC-MS to locate these otherwise indistinguishable contaminated kernels.

Beneficiaries

Since a final instrument and corresponding method have not yet been fully developed, the project's specialty crop commodities have not yet seen direct results. Upon successful development of the portable system, in-field analyses will help to remove fungal hot spots within stored nut locations. Removed hot spots can subsequently be compared to actual damage numbers obtained from current aflatoxin detection numbers. When ARS lab personnel will have completed the project, beneficiaries will include growers and handlers of California pistachio and almonds: Wonderful Orchards, California Pistachio Research Board, and Almond Board of California. If fully successful, immediate impact will initially only effect the processing stream and the processors themselves. This will be as a result of the processors pulling out the hot spots identified by detector. A broader impact to the entire industry (growers, processors, shippers) will not take effect until the detector has consistently proven a high percentage efficacy for removing hot spots and corroborates and exceeds current testing standards. Currently, aflatoxin contamination causes millions of dollars in damage to the tree nut industry (lost product, analyses costs, and rejected shipments). If even 10%

of hot spots were detected and removed from the food stream, this could save the industry hundreds of thousands of dollars, annually. Incorporation as a regulatory standard would take several years and standardized testing by other labs. Economic impact will show as reduced cargo rejection and increased amounts of safer product.

Lessons Learned

The project collaborator, Torion Technologies, was able to design and manufacture an injector and needle trap system specifically for the portable GC-MS instrument, and specifically for this project. However, obstacles remain for a successful product for reliable detection (sufficient for regulatory standards) of fungal contamination. Some specifics of experiences are as follows: An injector/needle trap system specific for pistachio and almond storage conditions. This general design can be applied toward the goals of the project and led to ideas that can be applied to non-storage conditions (e.g., processing, conveyor belt). Exploration of the condition of stockpiled almonds (hull split, relatively dry hull and shell) led to the discovery of normally non-visible mold hidden in the crack between hull and shell. This observation led to the discovery of biomarker volatiles from kernels inside and visually flawless, emitting different volatiles than kernels from 'clean, non-moldy' hulls/shells (See figures below). Working with newly designed and manufactured prototypes led to delays while trouble-shooting and diagnostic evaluations were performed. Lesson learned was to factor in additional time and anticipate delays in research.

Figure 1: There was hidden mold between split hull and shell of stockpile almond. Mold was not visible prior to pulling apart of hull sides. Figure 2 kernel (front) showed no indication of moldy hull/shell. Figure 3 kernel (back) showed no indication of moldy hull/shell.

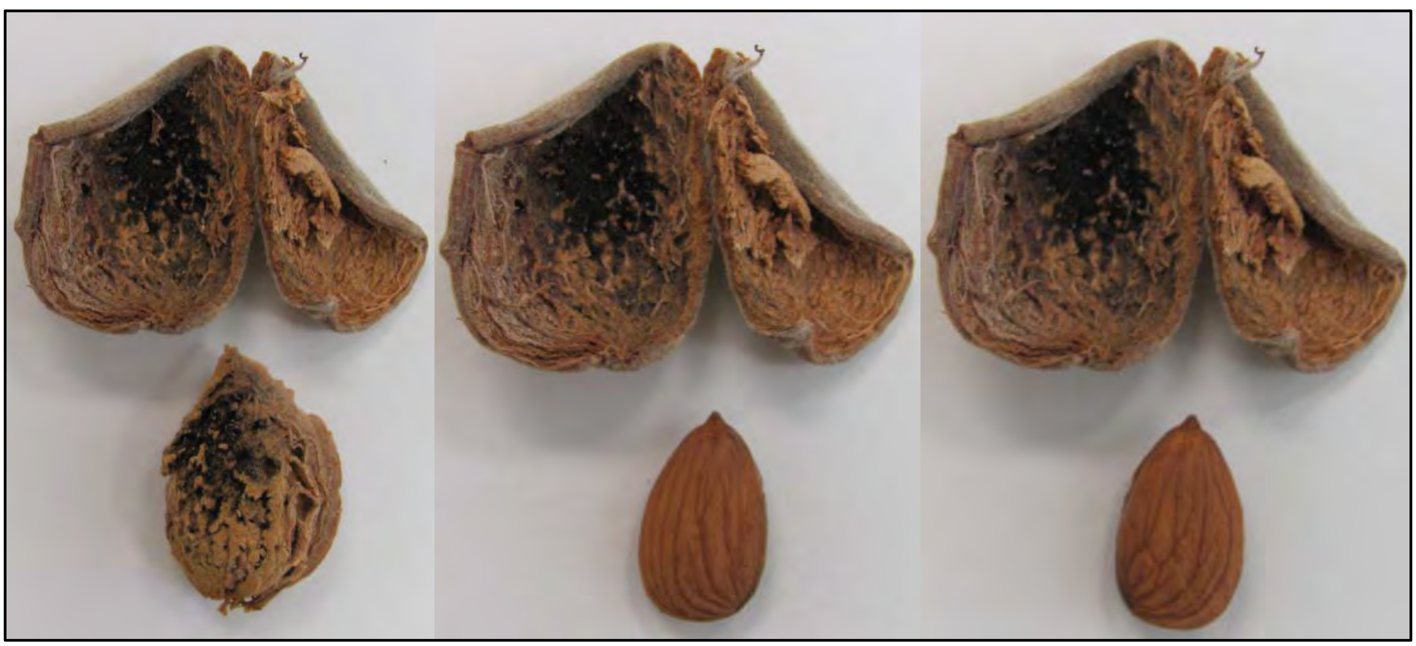

Figure 1 Figure 2 Figure 3

The objective of evaluating stockpiles or silos for contaminated product was ideal for implementing the initial designs and methods. However, further research into the unexpected result of 'hidden' mold that would not be typically seen by almond hullers led to other evaluation points or change in processing culture to remove these hidden mold spots on hulls/shells. Product from stockpiles is typically taken direct to a huller, which removes the hull and shell. Since the fruit that is encased in these moldy samples looks identical to the vast majority of fruits from non-moldy hulls, they are unrecognizable by sorting practices that use visual cues on the kernel to separate. Once further research is performed on whether these kernels exhibit aflatoxin compared to the ubiquitous 'clean' kernels, a better direction for subsequent projects will be determined. The result of 'hidden' mold was discovered towards the end of the project term. In depth investigations are currently underway and will include analysis of aflatoxin levels and any correlation to hidden mold, as well as volatile profiles.

Also, the presence of internal versus external fungi may present a problem for calibrating instrumentation prior to implementation under field and/or processing conditions. However, the detection of the biomarkers from kernels that were encased in moldy hulls/shells represented a major discovery that will require more research by this ARS laboratory to fully realize the potential impact.

Additional Information

Invited presentation: Volatiles from developing fungal spores as early warning signals of fungal contamination and their detection by portable GC-MS systems. Beck, J.J.; Porter, N.; Mahoney, N.E.; Gee, W.S. Recent Advances in Food Analysis (RAFA) 7th International Symposium, Prague, Czech Republic. Nov. 3-6, 2015
Publication: to outline capabilities of portable system – this publication was an interim paper while we awaited stockpile and storage nuts for analysis. Beck, J.J.; Porter, N.; Cook, D.; Gee, W.S.; Griffith, C.M.; Rands, A.D.; Truong, T.V.; Smith, L.; San Román, I. In-field volatile analysis employing a hand-held portable GC-MS: emission profiles to differentiate intact and damaged yellow starthistle flower heads. Phytochem. Anal. Online 6/11/2015

Publication in preparation, anticipated by end of December, 2015: Beck, J.J.; Porter, N.; Cook, D.; Gee, W.S.; Mahoney, N.E. Differentiation of stored tree nut volatile profiles at varying relative humidity levels using benchtop and portable GC-MS: part 1 – stockpiled almonds. For submission to Phytochem. Anal.

Publication in preparation: Mahoney, N.E.; Gee, W.S.; Cook, D.; Beck, J.J. Hidden mold between split hulls and shells of stockpiled almonds influences kernel volatile emissions. For submission to J. Agric. Food Chem.

California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.:	Project Title:	
62	Novel Coating Systems with Sustained Release of Food Antimicrobials to Improve Safety of Cantaloupe	
Grant Recipient: University of California, Davis Center for Produce Safety (CPS)	**Grant Agreement No.:** SCB12062	**Date Submitted:** December 2015
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** (530) 757-5777	**Email:** bonnie@centerforproducesafety.org

Project Summary

Cantaloupes have been linked to several outbreaks of foodborne illnesses. A total of 1,434 people became ill after consumption of contaminated cantaloupes in 1983-2002 (Bowen et al., 2006). A recent multistate outbreak of listeriosis associated with cantaloupes caused 84 cases of infections in 28 states, 33 deaths, and 1 miscarriage in 2011 (CDC, 2011).

Many strategies have been investigated to improve the safety of fresh specialty crops. Chemical sanitizers such as chlorine and peroxyacetic acid are commonly studied, but the interference of organic matters originating from fresh specialty crops during washing reduces the sanitation effectiveness (Rodgers et al., 2004). Surface roughness of fresh produce is another important factor that affects the effectiveness of sanitation. Surface roughness was positively and linearly correlated to the adhesion rate of bacteria while negatively and linearly correlated to inactivation efficiency of acidic electrolyzed water and peroxyacetic acid, as demonstrated for the lower efficiency on cantaloupes than avocado, oranges, and apples (Wang et al., 2009). Surfactants (detergents) can facilitate sanitizer solution to reach cavities harboring pathogens and therefore sanitation effectiveness, as was recently reported (Xiao et al., 2011). Other strategies including pulsed electric field, UV radiation, e-beam irradiation, chlorine dioxide gas, and ozone gas (Selma et al., 2008; Trinetta et al., 2011) have also been studied, but these technologies have not yet been used in the fresh specialty crop industry.

Because there is no single technology that can completely inactivate pathogens on specialty crops, the ability of pathogens to recover after sanitation is a big concern. For example, washing treatments using 5% hydrogen peroxide or 1,000 ppm chlorine significantly reduced *Salmonella* Stanley on cantaloupes, but the bacterium recovered after storage above 4°C (Ukuku and Sapers, 2001). Novel strategies are needed to ensure the safety of cantaloupes throughout shelf-storage.

Edible antimicrobial films and coatings are promising strategies to improve safety and quality of fruits and vegetables. Essential oils (EOs) are natural antimicrobials that are effective against a broad spectrum of foodborne pathogens. EOs are volatile and their loss from coatings can reduce the antimicrobial effectiveness during storage. The loss/release of EOs can be controlled by encapsulation in colloidal particles, and further controlled by blending with non-volatile lipids such as soybean oil (SBO). Surfactants used to prepare these colloidal systems can reduce the interference of surface roughness to improve the antimicrobial effectiveness of coatings.

The overall project goal was to improve safety and quality of cantaloupes by polysaccharide coatings with EOs and SBO. The first objective was to identify conditions of preparing clear oil/water/surfactant mixtures of EOs. The rationale of using clear mixtures is to prepare clear films/coatings that will not interfere the appearance of cantaloupes. Stable and transparent oil/water/surfactant mixtures were formulated by simple mixing and characterized their physical and antimicrobial properties. The second objective was to characterize physical properties of films and release properties of EOs to predict properties of coatings on cantaloupes. Two sets of clear films were studied for clear and turbid mixtures. The third objective was to evaluate effectiveness of coatings inhibiting spoilage and pathogenic microorganisms on cantaloupes. Besides clear mixtures, two turbid mixtures were studied. The fourth objective was to assess the cost of antimicrobial coatings and impacts on cantaloupe quality.

Cantaloupes have been linked to several outbreaks of illnesses due to contamination by foodborne pathogens. Also, cantaloupes have a limited shelf life due to the continued ripening and microbial spoilage during storage. Washing cantaloupes with sanitizers has limited effectiveness, and the contaminating pathogens can recover and grow during storage. This project studied the use of generally-recognized-as-safe antimicrobial preservatives to coat melons and maintain effectiveness during storage. The findings showed that the novel coating systems used in this study are effective in improving the safety and quality of whole cantaloupes. Application of these coatings on cantaloupes and other fruits and vegetables can benefit consumers, producers, and retailers.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

The overall goal of this project was to improve safety and quality of cantaloupes using novel coatings formed with polysaccharides and EOs. Because EOs are volatile, SBO was studied to reduce their evaporation during storage. The first objective was to formulate and characterize mixtures with oil, water, and surfactants. Clear mixtures were successfully formulated with Tween 80 as a surfactant and EOs and SBO at mass ratios of 1:0, 2:1, or 4:1. Phase diagrams were developed summarizing these formulations and studied physical bases of forming these clear mixtures. Physical properties were characterized such as viscosity and droplet dimension of these mixtures, as well as the stability. These clear mixtures were shelf-stable for more than 3 months. The antimicrobial activities of these mixtures were characterized and there was a reduction of activities when compared to free EOs dissolved in ethanol, with cinnamon bark oil (CBO) maintaining the highest antimicrobial activities. Lauric arginate (LAE), another surfactant that is an effective antimicrobial, was also studied. Synergistic antimicrobial activities of LAE and cinnamon oil (CO) in the presence of ethylenediaminetetraacetate (EDTA) were observed.

To understand and predict the effectiveness of antimicrobial coatings on cantaloupes, the second objective was devoted to study physical, mechanical, and antimicrobial activities of films prepared from polysaccharides, antimicrobials, and surfactants. Two sets of films were prepared and characterized. The first set of clear films was prepared from clear oil/water/surfactant mixtures and chitosan and was compared to opaque films prepared from turbid mixtures with less surfactants. Clear films had favorable physical properties for coating applications and were more effective than opaque films in retaining CBO during storage. The second set of films was prepared with 1%w/v sodium alginate, 0.5% w/v Tween 80, 0-2% w/v

CBO and 0-1% w/v SBO. These films also had desirable physical properties, and the addition of SBO improved the retention of CBO in films during storage. Films had good antimicrobial activities when tested against bacteria cocktails made of five strains/serovars each of *Listeria monocytogenes*, *Salmonella enterica* and *Escherichia coli* O157:H7.

In the third objective, three coating mixtures were studied for inhibition of pathogens inoculated on whole cantaloupes and native microflora: (1) 1% chitosan and clear oil/water/surfactant mixtures with 2% CBO, (2) 1% w/v alginate and 2% w/v CBO with 0 or 0.5% w/v SBO, and (3) 1% w/w chitosan, 0.1% w/w LAE, 0.1% w/w EDTA, and 0, 0.5, or 1% w/w CO. Overall, coating treatments were effective in inhibiting the inoculated pathogens and the growth of native molds and yeasts, especially after addition of SBO for alginate-based films. The first formulation, as originally planned, was the most expensive and had the least antimicrobial effectiveness. The second and third formulations were studied for impacts of coatings on cantaloupe quality in the fourth objective. Antimicrobial coatings slowed the color change and improved the firmness of cantaloupes, and had no impacts on other quality parameters. Additionally in the fourth objective, costs of the second and third coating formulations were estimated to be less than 1 cent per cantaloupe. The project findings showed the potential application of the two coating mixtures to improve the quality and safety of cantaloupes.

This project only studied the effects of coatings on quality and safety of cantaloupes; however, it is expected the technology can be applied to other specialty crops. This project only benefited specialty crops.

Goals and Outcomes Achieved

The completed activities in the project include these milestones:

1. Preparation and characterization of clear mixtures with EOs and SBO at mass ratios of 1:0, 2:1 or 4:1. In addition to formulations, viscosities and electric conductivity were studied to understand the structures of these mixtures. Antimicrobial activities of these mixtures also were determined. These stable mixtures are prepared by simple mixing and do not require sophisticated equipment.

2. Cast-films prepared with chitosan and clear CBO/SBO mixtures. Physical, mechanical, and antimicrobial properties of chitosan films with CBO and SBO were characterized. The loss of CBO from films during ambient storage was compared to control films prepared with turbid mixtures with less surfactant.

3. Cast-films prepared with sodium alginate and turbid CBO/SBO mixtures. Physical, mechanical, and antimicrobial properties of alginate films with CBO and SBO were characterized. Although the mixture was turbid, the films prepared were clear after addition of SBO. These films with less surfactant had good activities against foodborne pathogens.

4. Inhibition of foodborne pathogens and spoilage microorganisms on cantaloupes after chitosan- and alginate-based antimicrobial coating treatments. Cantaloupes were inoculated with foodborne pathogens and dipped in chitosan- and alginate-based CBO/SBO mixtures. The survival of pathogens during storage was studied. Chitosan-based coating mixtures with and without CBO were similar in inhibiting pathogens and were not studied further. Alginate-based coatings with CBO and SBO completely inhibited pathogens during

14-day storage. Additionally, alginate coatings with CBO, especially with additional SBO, effectively inhibited the growth of native molds and yeasts, which improves microbial quality of cantaloupes.

5. Impacts of alginate-based coatings with CBO and SBO on quality of whole cantaloupes. After coating treatments, cantaloupes were tested for color, firmness, total soluble solids, and weight loss. Coatings with CBO delayed the color change and softening of cantaloupes but had no effects on other quality parameters.

6. Estimation of costs of antimicrobial coatings. Costs of alginate-based coatings with both CBO and SBO were estimated to be less than 1 cent per cantaloupe.

Additionally, another combination of antimicrobials was studied, using antimicrobial surfactant LAE to reduce the cost of Tween 80 and EOs.

7. Antimicrobial properties of mixtures with LAE and CO. LAE is an effective antimicrobial but the combination of LAE and EOs can result in lower activities than LAE alone. The addition of EDTA resulted in the increased antimicrobial activities of LAE with and without CO. This synergistic activity is significant in reducing their usage levels while ensuring food safety.

8. Impacts of chitosan-based coatings with LAE, CO and EDTA on safety and quality of whole cantaloupes. Similar to alginate-based coatings, inhibition of pathogens and spoilage microorganisms on cantaloupes were observed after coating with 1% w/w chitosan, 0.1% w/w LAE, 0.1% w/w EDTA and 0.5 or 1% w/w CO. Positive impacts of these coating mixtures on quality of cantaloupes were also observed. Costs of the coating mixtures were estimated, also below 1 cent per cantaloupe.

The laboratory project showed that these cost-effective antimicrobial coatings are effective in improving the safety and quality of cantaloupes. These findings are to be verified in pilot and industrial settings.

The overall goal was to study antimicrobial coatings with EOs that are effective in inhibiting foodborne pathogens on cantaloupes and improving the quality. Two such coating formulations were found that can achieve the goal during 14-day storage of cantaloupes at room temperature.

For the first objective, clear mixtures were successfully formulated with Tween 80 as a surfactant and EOs and SBO at mass ratios of 1:0, 2:1, or 4:1. Besides formulations, antimicrobial and physical properties of these mixtures were characterized, as proposed. In addition, another promising formulation was studied that makes the antimicrobial activities of LAE and CO synergistic. These properties were used to choose formulations for studies in the subsequent objectives.

For the second objective, physical, mechanical, and antimicrobial properties of films prepared from two types of polysaccharides and two forms (clear and turbid) of oil/water mixtures were studied to understand and predict the effectiveness of antimicrobial coatings on cantaloupes. The mixture with 1%w/v sodium alginate, 0.5%w/v Tween 80, 2%w/v CBO and 0.5% w/v SBO showed promise for coating cantaloupes.

For the third objective, survival of pathogens inoculated on whole cantaloupes was studied after coating with three types of mixtures. Two mixtures (1% w/v alginate, 0.5% w/v Tween 80, 2% w/v CBO, and 0.5% w/v SBO; 1%w/w chitosan, 0.1% w/w LAE, 0.1% w/w EDTA, and 1% w/w CO) effectively inhibited *L.*

monocytogenes, *S. enterica* and *E. coli* O157:H7 on cantaloupes during 14-day storage at room temperature. Coatings also inhibited the growth of native microflora on cantaloupes.

For the fourth objective, the two mixtures identified in the third objective were studied for the impact on cantaloupe quality. Antimicrobial coatings with CBO slowed the color change and improved the firmness of cantaloupes, and had no impacts on other quality parameters. Costs of these coating mixtures were estimated to be less than 1 cent per cantaloupe.

The most significant findings translatable to the specialty crop industry are the two cost-effective coating formulations developed: (1) 1% w/v alginate, 0.05% w/v $CaCl_2$, 0.5% w/v Tween 80, 2% w/v CBO, and 0.5% w/v SBO; and (2) 1% w/w chitosan, 0.5% w/w acetic acid 0.1% w/w LAE, 0.1% w/w EDTA and 1% w/w CO. These coatings are promising to improve the safety and quality of cantaloupes and possibly other specialty crops.

Beneficiaries

Findings from this project showed that the studied coating formulations can effectively improve the safety and quality of cantaloupes. The data can directly benefit melon producers to reduce the outbreak of foodborne illnesses and extend the shelf-life of melons. Coating systems also can be applied to other specialty crops if similar improvements can be verified.

Findings will be presented in refereed publications and scientific meetings; manuscripts for submission to scientific journals are currently in preparation. The project findings will reach both scientific community and the cantaloupe industry to improve the safety of fresh cantaloupes.

The outcomes of this research can be directly applied to the entire cantaloupe industry, which in 2007 involved over 9,000 farms nationwide. According to the most recent (2012) Census of Agriculture there are 6,155 farms that grow crops including melons, vegetables, potatoes and sweet potatoes, which represent over $6.3 billion in sales in the state of California (http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Rankings_of_Market_Value/California/index.asp).

The potential economic impact of the project also includes the following:

Antimicrobial coatings are effective in inhibiting pathogens on cantaloupes and likely other fresh produce products. The adoption of coatings can reduce the outbreaks of foodborne illnesses. This impacts the well-being of numerous consumers and reduces economic losses due to hospitalization, law suits, and recalls.

Antimicrobial coatings are effective in slowing the ripening of melons and inhibiting spoilage microorganisms. Therefore, the reduced loss of melons due to undesirable quality can benefit producers, retailers, and consumers.

These antimicrobial coatings cost less than 1 cent per melon. This additional cost can be offset by the above two advantages.

The Principal Investigator presented final research results in June at the 2015 CPS Produce Research Symposium in Atlanta, Georgia. Interim results were presented previously at the 2014 CPS Produce

Research Symposium in Newport Beach, California. Both symposia had approximately 245 attendees. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academics, produce industry representatives, and members of regulatory agencies. The annual symposium provides expert panels to critique the research results after presentation by the researcher, which helps participants evaluate how the results can be used in their respective businesses.

Project results will be disseminated at industry meetings, and streamed through social media sources. Results also will be made available online as follows:

1. Final reports will be posted on the CPS website: http://www.centerforproducesafety.org/grant_opportunities_awards.php
2. CPS works with the scientists to publish results in scientific journals. Publication dates occur after the project is completed. Abstracts and awards can be found on the CPS website.
3. The Board of Directors and members of the Technical Committee of CPS distribute a series of information briefs throughout the year on the website and through presentations, meetings and webinars. An example of this would be the “2014 CPS Symposium: 10 Lessons Learned” on the CPS website at the following link: http://www.centerforproducesafety.org/amass/documents/document/246/FINAL_2014%20CPS%20Research%20Symposium%20Lessons%20Learned%202%20August%202014_Final.pdf.

The following websites provide additional resources on the final reports and symposium proceedings:

Center for Produce Safety: http://www.centerforproducesafety.org/resources.php
Produce Marketing Association: http://pma.com
Western Growers Association: http://www.wga.com/

Lessons Learned

This project took a typical academic approach. Considerable time was spent to study formulations that enable the preparation of clear oil/water/surfactant mixtures. These formulations are scientifically interesting but are more costly than turbid mixtures. Later, the team found out both clear and turbid mixtures can be used to prepare clear films. With this direction, two coating mixtures were also studied that are less costly and more practical, while achieving the project goals. A large amount of data was collected that can result in more than 7 papers and also be used by the specialty crop industry. Finally, the team would like to study these coating systems for other fruits such as berries, grapes, and apples.

Originally, the team expected that transparent films can only be prepared from clear oil/water/surfactant mixtures. These clear mixtures require a large quantity of surfactants that can bind with EOs and therefore reduce the antimicrobial activity. Fortunately, transparent films were observed from formulations with a small amount of surfactants, thus achieving the project goals.

The ambitious research plan proposed demanded a lot more work than initially anticipated. Decisions made along the way were based on the practicality in the specialty crop industry. Two coating formulations that were not initially proposed were studied. These coating formulations meet the original project goal but are less costly.

Securing melons was not a simple matter due to the quantities used in the project. The team had a commitment from growers in Georgia but supplies were not available when melons were needed in July 2014, so melons had to be purchased (from Walmart), and the Center for Produce Safety arranged a supply of melons for the last study.

Additional Information

Submitted publications and poster presentations include:

Ma, Q. and Q. Zhong. Formulating fully-dilutable microemulsions of plant essential oils blended with soybean oil. *Food Research International*. Revision submitted.

Ma, Q., Y. Zhang, F. Critzer, P.M. Davidson, and Q. Zhong. Quality attributes and microbial growth on whole cantaloupes with antimicrobial coatings containing chitosan, lauric arginate, and cinnamon oil. The 2015 IFT Annual Meeting, July 11-14, Chicago, IL. (Submitted)

Ma, Q., Y. Zhang, and Q. Zhong. Physical and antimicrobial properties of chitosan films incorporated with lauric arginate, cinnamon oil and ethylenediaminetetraacetic acid. The 2015 IFT Annual Meeting, July 11-14, Chicago, IL. (Submitted)

Ma, Q., Y. Zhang, F. Critzer, P.M. Davidson, and Q. Zhong. Synergistic antimicrobial activity of lauric arginate and cinnamon oil against foodborne pathogens in the presence of ethylenediaminetetraacetic acid. The 2015 IFT Annual Meeting, July 11-14, Chicago, IL. (Submitted)

Zhang, Y., Q. Ma, F. Critzer, P.M. Davidson, and Q. Zhong. Effects of alginate coatings with cinnamon bark oil and soybean oil on quality and safety of cantaloupe. The 2015 IFT Annual Meeting, July 11-14, Chicago, IL. (Submitted)

Zhang, Y., Q. Ma, F. Critzer, P.M. Davidson, and Q. Zhong. Physical and antibacterial properties of alginate films containing cinnamon bark oil and soybean oil. The 2015 IFT Annual Meeting, July 11-14, Chicago, IL. (Submitted)

Ma, Q., M.F. Critzer, P.M. Davidson, S. Zivanovic, and Q. Zhong. 2014. Physical properties of chitosan films with microemulsions of incorporated cinnamon bark oil. The 2014 IFT Annual Meeting, June 21-25, New Orleans, LA. Paper # 206-40 (poster presentation).

Ma, Q., M.F. Critzer, P.M. Davidson, and Q. Zhong. 2013. Formulating fully-dilutable microemulsions of plant essential oils by blending with soybean oil. The 2013 IFT Annual Meeting, July 13-16, Chicago, IL. Paper # 255-146 (poster presentation).

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Wang, H., Feng, H., Liang, W., Luo, Y., & Malyarchuk, V. (2009). Effect of surface roughness on retention and removal of *Escherichia coli* O157: H7 on surfaces of selected fruits. *Journal of Food Science, 74*(1), E8-E15.

Xiao, D., Ye, R., Davidson, P. M., Hayes, D. G., Golden, D. A., & Zhong, Q. (2011). Sucrose monolaurate improves the efficacy of sodium hypochlorite against *Escherichia coli* O157: H7 on spinach. *International Journal of Food Microbiology, 145*(1), 64-68.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 63	**Project Title:** Science-based evaluation of risks associated with wildlife exposure for contamination of irrigation water by Salmonella	
Grant Recipient: The Regents of the University of California, Davis, Center for Produce Safety	**Grant Agreement No.:** SCB12063	**Date Submitted:** December 2014
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** 530-757-5777	**Email:** bfernandez@cps.ucdavis.edu

Project Summary

Salmonella is the most common bacterial foodborne pathogen in the United States, and salmonellosis is increasingly associated with produce contamination (Gould et al. 2011). Irrigation water is a recognized risk factor for contamination of produce; however, the impact of wildlife as a source for this foodborne pathogen in irrigation water remains uncertain. Some growers have resorted to using ground water as the sole source for irrigation or have cleared vegetation in an attempt to exclude wildlife from these reservoirs. Salmonella enterica is distributed throughout the environment and can be recovered from various wildlife reservoirs, and different animal host species appear to be associated with different strains of Salmonella that are likely to represent a range of disease potential in humans.

Assessment of pathogen risk for agricultural water intended for pre-harvest contact now relies on periodic testing for generic Escherichia coli as described in the Produce Safety Rules within the 2013 Food Safety Modernization Act: No more than 235 colony forming units (CFUs) generic E. coli per 100 ml for a single water sample, and a rolling geometric mean of five samples of no more than 126 CFU per 100 ml. Unfortunately, fecal indicator bacteria may not provide reliable estimates of Salmonella contamination due to the greater persistence of this pathogen and because pathogen detection methods have lacked the sensitivity needed to detect low levels of Salmonella that are generally present in aquatic environments. Thus, the motivation for this project was to assess the potential risk of Salmonella contamination of produce by investigating the distribution and virulence potential of Salmonella associated with irrigation ponds and the wildlife inhabiting those ponds.

The current research leveraged results from two previously funded Center for Produce Safety (CPS) projects, namely "Science-based evaluation of regional risks for Salmonella contamination of irrigation water at mixed produce farms in the Suwannee River watershed" and "Evaluation of amphibians and reptiles as potential reservoirs of foodborne pathogens and risk reduction to protect fresh produce and the environment" (UC Davis PI). These studies investigated some of the same irrigation ponds on multiple small farms with various vegetable and fruit crops in the upper Suwannee River Watershed in Georgia. This region was selected because it is a "hot spot" for environmental sources of salmonellosis with case rates that were 1.5 times higher than the national average (CDC, 2009). In these studies Salmonella was isolated from water and/or sediment at all ponds examined (n=10) and from 15 (37.5%) of 40 toad, 23 (18.4%) of 125 turtle, 2 (40%) of 5 bivalve samples taken from a subset (n=5) of these ponds (UC Davis, CPS Final Report). Salmonella was frequently detected when indicator levels were below the recommended standards described above. Goals for the present research were to establish a phylogenetic database for Salmonella from agricultural and environmental sources, as well as from outbreak-associated strains provided by collaboration with Food & Drug Administration (FDA), Centers for Disease Control (CDC), and the Florida Department of Health. Genetic analyses were based on molecular typing systems (pulsed field gel electrophoresis and DiversiLab rep-PCR) and will be validated by whole genome sequencing. Thus, the research has now established regional genetic profiles for Salmonella strains based on source and geographic location. Recent advances in next generation sequencing technologies offers the promise of whole genome sequence analysis as a feasible approach to predicting virulence potential, and the ultimate goal will be to develop predictive models that can be used to implement improved agricultural practices and education programs that will reduce contamination of produce.

Project Approach

Different animal host species have been reported to be associated with different strains of Salmonella and are likely to represent a range of disease potential in humans. Salmonella strains recovered from wildlife, irrigation pond water, and sediments sources were proposed to be examined in order to make genetic comparison to strains from human disease. Environmental isolates were from the same geographic region, which encompassed 10 ponds in southwest Georgia. Evaluation of disease potential of these strains was accomplished by examining these strains and additional strain collections using PCR-based rapid diagnostics, pulsed field gel electrophoresis (PFGE) analysis DiversiLab repetitive PCR based typing (rep-PCR), and whole genome sequencing (WGS). Strains were also examined for antibiotic resistance. This research is now linked through WGS to the FDA-sponsored Next Generation Sequencing Project. This project will integrate WGS data nationwide and internationally in order to eventually provide a large public genomic database that can be used for source-tracking outbreaks, monitoring agriculture, and predicting virulence of Salmonella strains. University of Florida is the southeastern representative of this project, and strains from several CPS-funded projects recovered in both Florida and Georgia are now a part of this collection. One of the goals for this research is to establish genetic markers that define the regional distribution and evolution of Salmonella associated with produce. Outcomes could also provide more rapid and accurate assessment of food products implicated in outbreaks in order to prevent the needless broad-based recalls that impact an entire industry. Additionally, these data shed light upon on potential risk imposed by exposure of wildlife to irrigation ponds and provide science-based data for establishing policy and management strategies for irrigation ponds. Objectives of research included the following:

1. Determine genetic relatedness of Salmonella strains isolated from wildlife relative to isolates from irrigation water and sediments in the same geographic region vs. strains from other sources in our database.

2. Validate genetic diversity and evaluate virulence potential by pulsed field gel electrophoresis using the PulseNet protocol (UC Davis) and by allelic variation of selected genes.

Objective 1 proposed to marry data for Salmonella genotyping based on rep-PCR of isolates from water and sediment samples of irrigation ponds (Wright Lab, 2010-2013) with a survey of Salmonella isolates derived from wildlife collected at the same ponds and genotyped by PFGE (UC Davis Lab in collaboration with University of Georgia). These samples provide a strain collection that included >2000 strains along with the numerous environmental parameters that were recorded from each sample site. To date evaluations on 200 strains, derived from pond water/sediment (n=223), wildlife (n=88), Suwannee River water (n=30), produce trace-back studies (n=55) or clinical sources (n=300) have been completed. For objective 2, the use of pulsed field gel electrophoresis and DiversiLab rep-PCR analysis to examine genetic diversity and relatedness of strains from irrigation ponds in relationship to strains from clinical sources was planned. Multilocus sequence typing was originally proposed to examine allelic variation; however, after joining the FDA next generation sequencing project, research efforts were focused on whole genome analysis of the strain collection as a more precise tool to evaluate strains and validate genetic assays. Thus, the strains collected from this research are now part of a much larger database, which also includes state public health labs, USDA, FDA, and CDC salmonella collections of clinical isolates.

There were no project partners in this particular project.

Goals and Outcomes Achieved

Research activities for this project are conducted by University of Florida subaward principal investigator.

Development of a novel cross-streaking method for enumeration and confirmation of Salmonella. One of the unexpected accomplishments of this research was to develop a novel "low tech" cost effective alternative to PCR for enumeration and identification of Salmonella. This outcome was a consequence of data analysis from prior CPS-funded research and was revealed during the process of building the strain collection for genetic analyses. Standard methods for recovery and enumeration of Salmonella generally include a most probable number (MPN) approach with dual enrichment in order to increase sensitivity and sample size. Selective agars are used to isolate presumptive positive colonies, which are confirmed by biochemical or molecular assays, such as the polymerase chain reaction (PCR). These methods are labor intensive and may require 3-5 days to complete. Thus, time-efficient and cost-effective detection methods for Salmonella from irrigation pond samples are needed for risk assessment and potential monitoring. The efficacies of six different downstream detection methods were tested for confirmation of Salmonella using different agars. Evaluation of enrichment broth samples (n=2646) from various water and sediment sources showed differences in performance of these agars as initial isolation agars with XLT4-showing the highest agar efficiency rate, lowest cost, and lowest labor intensity due to fewer false positive results. Also, it was noted that an improved strategy might be to identify presumptive positive colonies on XLT4 plates at 20 rather than 24 hours of incubation, as suggested by the manufacturer's protocol, since an increase in the false positive rate for colonies after 20 hours of incubation was observed (data not shown). Based on these results, a cross-streaking method was developed and represents a new discovery. The method involves sequential isolation (cross-streaking) of typical colonies from the primary isolation agar (XLT4), followed by subsequent evaluation on the secondary agar (CHROMagar Salmonella Plus, CSP). This method was highly predictive for colony identification by PCR: 99.99% of isolates that are positive on both agars were also confirmed as Salmonella positive by PCR (n=1611), only one isolate was found to be PCR positive, CSP positive, but negative on XLT4. The cross-streaking method was highly performant: sensitivity=0.99, specificity=1.00 with significantly reduced cost per assay (Table 1).

Antibiotic resistance of wildlife vs. pond isolates. Strains collected from wildlife (n=40) and strains collected from pond water and sediments (n=130) were examined for resistance to a battery of antibiotics (n=14). Most strains (76%) were resistant to streptomycin for both groups. Multiply resistant strains (8%) were generally limited to streptomycin and one other antibiotic (Ampicillin, Nalidixic Acid, Trimethoprim, Cefoxitin, or Kanamycin), and were distributed evenly among wildlife vs. pond strains. One from a turtle (Cephalothin, Kanamycine, Streptomycin) and one from water (Ampicillin, Nalidixic Acid, and Streptomycin) were resistant to 3 antibiotics.

Molecular typing analyses. PFGE analysis has been completed for a total of 380 strains of Salmonella either as part of this study or from prior research. Strains from wildlife (n=150) were obtained from 5 ponds. Strains (n=148) from sediment and water were derived from all 10 ponds. Strains (n=30) from the Suwannee River from a previous study and strains (n=52) obtained from produce trace-back studies by the Florida Department of Agriculture were also PFGE typed. DiversiLab rep-PCR has been completed on a total of 380 strains. Including strains from wildlife (n=70), pond water or sediment (n=280), and from the Suwannee River (n=30). Whole genome sequencing (WGS) has been completed on 248 strains including wildlife, pond water and sediment, the Suwannee River strains, and strains obtained from produce trace-back studies by the Florida Department of Agriculture, as well as isolates from the Emerging Pathogens Institute from various sources. Comparative analysis for PFGE and rep-PCR showed a total of 83 PFGE types and 16 rep-PCR types that were identified from alignments for a subset of strains from pond water and sediments were aligned (n=182). The greater diversity observed by PFGE compared to rep-PCR was based on the level of discrimination and the criteria used for cluster determination. Cluster of rep-PCR was based on 80% similarity; single band difference was the criteria for PFGE discrimination. Thus, strains within a single rep-PCR cluster frequently showed multiple PFGE types. There was some agreement observed between the two methods, and most strains that clustered by one assay were frequently grouped by the other (59%). Future alignments will adjust these parameters in order to improve these comparisons. Five strains untypeable by PFGE were discriminated by rep-PCR. Based on PFGE, strains did not cluster by pond or season. Interestingly, many genotypes (20%) from wildlife strains were unique for a single sample. However, multiple genotypes were observed for any particular host species, and were not recovered from other species or from water or sediment. Other genotypes were less specific and clustered with different species and/or water samples.

<u>Assessing virulence potential.</u> Virulence potential can be assessed by using molecular typing methods to examine the genetic similarity of environmental strains compared to those derived from clinical infection. Using rep-PCR, a prior study showed Salmonella strains isolated from the Suwannee River were a genetically distinct population from those commonly associated with disease, in that they mostly clustered (<85% similarity) with each other and generally did not cluster with clinical strains (Rajabi et al., 2011). Conversely the clinical strains generally clustered with each other and not with environmental isolates. The project team used this approach to estimate virulence potential of strains collected from water or sediment sources derived from the 10 ponds described above. The data showed that pond water and sediment strains were mostly (50% of n=200) grouped with strains from clinical origin (designated as C-type), while clusters with environmental sources (designated as E-type) were much less frequent (35%). The remaining strains (15%) appeared to be unique to the database and only clustered with other pond strains. In contrast, strains from wildlife origin were predominantly E-type (87%) and only 10% of wildlife strains were C-type with the remaining strains unique. Based on PFGE analysis, strains did not cluster by pond or season. Interestingly, many genotypes (20%) from wildlife strains were unique for a single sample. However, multiple genotypes were observed for any particular host species, and were not recovered from other species or from water or sediment. Other genotypes were less specific and clustered with different species and/or water samples. The data illustrates the diversity of strains from environmental sources and indicate that strains from wildlife are less likely to have a present risk to human health than are strains in the water and sediment.

<u>Whole genome sequence molecular typing.</u> To date, 248 Salmonella genomes have been sequenced. Preliminary phylogeny of a subset of WGS maximum likelihood analysis of single nucleotide polymorphisms (SNPS) showed good agreement (about 70%) with rep-PCR. WGS analysis is ongoing, and >400 genomes are to be completed by the end of the year. In addition to contributing to the national WGS database of Salmonella isolates, the project team is using this opportunity to compare phylogenies based on WGS data with PFGE and other typing methods. The demographic history of this pathogen in Florida and Georgia are being explored using a longitudinal assessment of isolates. What is revealed is a complex dynamic of isolates collected from

environmental and wildlife sources across north-central Florida and South Georgia. This technology promises to enhance the current national surveillance framework, as well as expand understanding of Salmonella ecology and transmission in Florida.

Perhaps the most important outcome of this project was to link the genomic project with the Florida Departments of Agriculture and Health. Recent comparison of different typing methods to whole genome sequencing has indicated that the methods lack the discrimination power of comparative genomics (Cao et al., 2013). PFGE was not able to discriminate highly clonal strains, and neither PFGE nor MLST correctly identified the relationship among lineages within different strains of Salmonella Newport that were apparent by WGS. Evaluation of WGS for outbreak detection found SNP analysis outperformed PFGE, but noted that the validation of this approach requires additional evaluation of different sequencing platforms, analytical procedures, and larger databases (Leekitcharoenpho, 2014). As more genomes become available and methods become standardized, WGS should provide a better understanding of the evolution and ecology of Salmonella subspecies and serotypes. With the advent of next generation sequencing platforms, high throughput is feasible, and genomic sequencing could provide the basis for the evolution of PulseNet into a similar network based on WGS, i.e. a "GenomeNet", that would provide rapid and much more accurate analysis for identifying strains associated with outbreak events. Potentially, these databases will help to define virulence potential of the wide repertoire of diverse Salomonella populations for more informed risk assessment, science-based policy decisions, and improved management strategies.

Beneficiaries

Farmers will benefit from lowered costs if auditing of irrigation pond for pathogens becomes required. There are 42,729 farms of produce crop growers representing $23.9 billion in sales in the state of California according to the 2012 Census http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Rankings_of_Market_Value/California/index.asp One of the accomplishments of this research was to develop a "low tech" cost-effective alternative to PCR. The cost for cross-streaking method was estimated to be $11.63 compared to $18.60 for the standard method with PCR confirmation of MPN on one sample. The cross-streaking method offers the specificity and sensitivity nearly equivalent to PCR without the requirement for specialized equipment or training. The method would allow for increased number of samples to be evaluated, and hence lower the limit of detection, which is always an issue for detection of pathogens in the environment. This method could benefit regulatory agencies by providing improved monitoring and assessment of risks associated with various agricultural practices and environmental conditions. It will help to more rapidly establish criteria for assessing the water safety and offer alternatives to fecal indicators that may not correlate with pathogen levels.

A Research Doctor from University of Florida presented a poster of interim results at the 2013 CPS Produce Research Symposium in Rochester, New York. Final research results were presented in June at the 2014 CPS Produce Research Symposium in Newport Beach, CA. The 2013 symposium had 300 attendees and the 2014 symposium had 245. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academic, produce industry representatives, and members of regulatory agencies. The symposium provides expert panels to critique research results. This process helps participants evaluate the use of the research results in their respective businesses. Project results will be disseminated at industry meetings and streamed through social media sources.

Final results will also be included in the following:

1. Final reports will be posted on the CPS website https://cps.ucdavis.edu/grant_opportunities_awards.php after the June 2014 symposium.
2. CPS also works with scientists to publish results in scientific journals. Publication dates occur after the project is completed. Awards and abstracts can be found on the CPS website.
3. The Center for Produce Safety's Board of Directors and members of the Technical Committee distribute a series of information throughout the year on their websites, and through presentations, meetings and webinars. An example of this would be the "CPS Funded Research - Key Learnings" on the CPS website at the following link: https://cps.ucdavis.edu/amass/documents/document/210/CPS%20Key%20Learnings%20May%202014_FINAL2.pdf

The following websites provide additional resources on the final reports and symposium proceedings:

Center for Produce Safety: https://cps.ucdavis.edu/resources.php
Produce Marketing Association: http://pma.com
Western Growers Association: http://www.wga.com/

Lessons Learned

One of the lessons learned was the importance of structured management of large databases, and the necessity for good communication between partners within a large collaboration. Fortunately, this process has been greatly facilitated by collaboration with FDA who provided not only training, salary and regent costs, but also the template for metadata management and frequent opportunity for conferencing. The project team is using FDA's methodology for the sequence analysis, but is also collaborating with the Associate Professor at the University of Florida Emerging Institute to examine alternative protocols for phylodynamic investigations. The goals of combined molecular typing comparison (PFGE and rep-PCR) of Salmonella from linked irrigation pond and wildlife sources were achieved, but are still in the process of completing the WGS analyses that will validate (or not) these comparisons.

One of the unexpected outcomes was the discovery of the cross-streaking method, which were a consequence of data analysis from prior research and the process of building the strain collection for genetic analysis in this study. The genetic divergence of strains from derived from water and sediment vs. those from wildlife was also not anticipated. Clearly a larger database of strains will be required for meaningful interpretation of the data. Although genetic similarity, Salmonella strains, derived in water and sediment samples to clinical strains may indicate potential risk for human disease, in general, strains from amphibians and reptiles did not appear to serve as a reservoir for these strains. Further study is recommended before the introduction of stringent measures to control wildlife access to irrigation water.

Additional Information

Publications

1. Luo, Z., G. Gu, C. G. Mihai, P. Adams, G. Vellidis, A. H. C. van Bruggen, A. C. Wright. Development of a novel cross-streaking method for isolation, confirmation, and enumeration of Salmonella from irrigation ponds. J. Microbiol. Methods. In Press. The manuscript has been assigned the control number AEM00954-14.

2. Luo, Z., G. Gu, P. Adams, G. Velidis, A. H. C. VanBruggen, M. Danyluk, A. C. Wright. Distribution and genetic diversity of Salmonella enterica isolated from Irrigation Water in the Suwannee River Watershed. (In preparation to Appl. Environ. Microbiol.)
3. Li, B. Vellidis, G, H., Liu, M. Jay-Russell, S. Zhao, Z Hu, A.C Wright, and C. Elkins. Improved Detection and Isolation Scheme Reveals Diversity and Persistence of Salmonella enterica Subtypes in Surface Water in Southeastern U.S. (under review by Appl Environ. Microbiol.
4. Gu, G., Luo, Z., Cevallos-Cevallos, J., Adams, P., Vellidis, G., Wright, A., and van Bruggen, A. 2013a. Factors affecting the occurrence of Escherichia coli O157 contamination in irrigation ponds on produce farms in the Suwannee River Watershed. Canadian Journal of Microbiology, 59(3): 175-82.
5. Gu, G., Luo, Z., Cevallos-Cevallos, J., Adams, P., Vellidis, G., Wright, A., and van Bruggen, A. 2013. Occurrence and population density of Campylobacter jejuni in irrigation ponds on produce farms in the Suwannee River Watershed. Canadian Journal of Microbiology, 59(5): 339-46.

Presentations

1. Li, B., J.-Q. Chen, M. Jay-Russell (WCFS), G. Vellidis (UGA), A. Wright (UF), Z. Hu, J. Gangiredla, S.A. Jackson, and C.A. Elkins (2013). Rapid Detection and Serovar Identification of Salmonella by Real-Time PCR and Microarray from Environmental Irrigation Water Sources. Poster presentation at the American Society for Microbiology. Denver, CO
2. Luo, Z. ,G.Gu, P. Adams, G. Velidis, A. VanBruggen, M. Danyluk and A.C. Wright. (2013) Distribution and Characterization of Salmonella enterica from Irrigation Water in the Suwannee River Watershed. Poster presentation at the International Association of Food Protection Annual Meeting.
3. Luo, Z., G.Gu, P. Adams, G. Velidis, A. VanBruggen, M. Danyluk and A.C. Wright. (2013) Science-based evaluation of regional risks for Salmonella contamination of irrigation water at mixed produce farms in the Suwannee River Watershed. Poster presentation at the Center for Produce Safety Annual Meeting. Rochester, N.Y.
4. Luo, Z., G.Gu, P. Adams, G. Velidis, A. VanBruggen, M. Danyluk and A.C. Wright. (2013) Science-based evaluation of risks associated with wildlife exposure for contamination of irrigation water by Salmonella. Rochester, N.Y.
5. Waterman, K.,T. Azarian, Z. Luo, M. Allard, A. C. Wright, J. Johnson, M. Salemi (2014) Whole-Genome Sequencing for National Surveillance of Enteric Diseases. UF EPI Research Day.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

<table>
<tr><td>USDA Project No.:
64</td><td colspan="2">Project Title:
Avirulent Salmonella strains and their use to model behavior of the pathogen in water, composts, in and on vegetables</td></tr>
<tr><td>Grant Recipient:
The Regents of the University of California, Davis, Center for Produce Safety</td><td>Grant Agreement No.:
SCB12064</td><td>Date Submitted:
December 2015</td></tr>
<tr><td>Recipient Contact:
Bonnie Fernandez-Fenaroli</td><td>Telephone:
530-757-5777</td><td>Email:
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</table>

Project Summary

Behavior of common indicator organisms and Salmonella in soil, organic amendments and water: the need for suitable non-pathogenic indicators of microbiological safety of the environment has long been recognized. However, even after a 40-year-long search for an ideal non-pathogenic indicator, the behavior of which correlates with that of pathogens, it has not been found. In general, *Salmonella* is commonly accepted as being better able to survive in the environment than *E. coli*, although *Salmonella* is not as common in the environmental samples as *E. coli* or coliforms. *Salmonella* can better persist in processed organic waste and amended soils than fecal coliforms, although its persistence appears to be strain- and/or site-dependent. The persistence pattern of *Salmonella* on surfaces of peaches, cantaloupes, lettuce, and bell pepper has been shown to be very different from that of *E. coli* (and/or select microbial indicators). These differences in survival and re-growth under field conditions and in vegetable production raise important questions about the suitability of indicators for predicting behavior of *Salmonella* in manure, irrigation water and in association with plants.

Field release studies using attenuated pathogens: The recognition that coliforms and other indicator organisms are poor predictors of the behavior of pathogens under field conditions led to studies in which attenuated enterohemorrhagic *E. coli* (EHCE) and *Salmonella* strains were released in the research fields in California and Georgia. EHEC mutants lacking *stx* genes (encoding the Shiga toxin), sometimes containing a plasmid-borne green fluorescent protein, were used. These seminal experiments with attenuated EHEC strains allowed an assessment of the impact of the pathogen on the overall numbers of phyllosphere bacteria; and the role of irrigation types and exposure to the sun in the ability of the pathogen to colonize specific sites on plants and to persist on crops. The availability of attenuated EHEC strains was instrumental in defining these aspects of pathogen ecology under the conditions that are relevant in the produce industry.

In the U.S., attenuated *Salmonella* appears to have been used in only two field studies, where a strain of *S.* Typhimurium (originally developed as a live oral vaccine) lacking the *cya/crp* global regulatory system was released. While incapable of eliciting disease symptoms in mice, this strain attaches to and persists in gut-associated lymphoid tissues and is fully capable of eliciting immune responses in animals. Most vaccine strains, including *cya/crp* mutants, have severe growth defects due to lesions in major catabolic and regulatory pathways. Under laboratory conditions, phenotypes of *cya* and *crp* mutants are unstable, and second site spontaneous compensatory mutants arise and become dominant very quickly, often already after overnight culture. Because virulence genes are otherwise intact, spontaneous second site mutations (for example in promoter regions controlled by CRP-cAMP) or gene conversions may arise and restore virulence to the released strains. With this proposed research, the project team aimed to develop mutants in which multiple loci of *Salmonella* pathogenicity genes are cleanly excised, thus making them incapable of invading animal hosts and eliciting disease, while maintaining those genes needed for normal growth in manure, soil, irrigation water and in or on plants.

Virulence determinants in Salmonella spp: The evolutionary divergence of *Salmonella* from *E. coli* 40 to 60 million years ago was associated with the acquisition of the *Salmonella* Pathogenicity Island (SPI)-1. The presence of SPI-1 is a distinguishing characteristic of all of the 2,200+ strains of *Salmonella*, and this feature is commonly used in *hilA*- and/or *inv*-based Polymerase chain reaction (PCR) protocols for the detection of *Salmonella* in environmental samples and produce. Genes located on SPI-1 are involved in the early events of the interaction of the pathogen with the host gut epithelial cells. SPI-1 is also present in generally avirulent *Salmonella bongori*, and genes located on it are not sufficient to cause disease. Sequential acquisition of SPI-2, SPI-3, SPI-4 and SPI-5 by *Salmonella enterica* led to strains that are virulent in multiple animal hosts. In addition to the pathogenicity islands, genes located on the *Salmonella* virulence plasmid contribute to virulence of some serovars. All these horizontally acquired virulence genes (on SPI's or virulence plasmids) are tightly integrated into bacterial regulatory cascades. Therefore, deleting many housekeeping regulators (such as *crp* and *rpoS*) reduces expression of virulence genes and results in attenuated pathogenicity. The type strain *S. enterica* sv Typhimurium LT2 contains a spontaneous mutation in *rpoS*, which is at least in part responsible for its avirulence. For the purpose of this proposal, a narrow definition of "virulence genes" as only those that are present in *Salmonella* (and not in its closest relative *E. coli*) was used and are directly involved in the interactions with animal hosts was used. This definition, therefore, excludes pleiotropic regulators, housekeeping and metabolic genes that are also present in avirulent sister lineages (other members of *Enterobacteriacea*) and indirectly contribute to virulence.

Under the Food Safety Modernization Act (FSMA), there are key provisions for on-site validation and testing of food safety protocols and justification of exemptions. However, on-site validation can only be done using avirulent strains that are safe for use outside of a laboratory. With this study, the project team developed and characterized an avirulent strain of *Salmonella* that should be suitable for such on-site studies.

Previous funding from the Center for Produce Safety supported characterization of the behavior of Salmonella in tomatoes as a function of the irrigation regime, water congestion and interactions with phytopathogens. Previous funding from 2009 SCBGP Project 49: *Reducing Tomato Contamination with Salmonella through Cultivar Selection and Maturity Harvest* allowed the project team to define mechanisms of interactions of Salmonella with tomatoes, which was an important baseline for this project.

Project Approach

With this study, the project team constructed a series of avirulent *Salmonella* strains, and engineered a multi-locus deletion strain lacking all five *Salmonella* Pathogenicity Islands, and its virulence plasmid; its suitability for field studies was tested. Several precautions were taken to generate this construct: pathogenicity islands were precisely excised, the strain does not harbor virulence plasmids, and the strain is free of features increasing its resistance to antibiotics. The strain was designed to fail PCR-based *Salmonella* detection approaches, however, it can still be identified using culture-based techniques. The surrogate strain can be distinguished (using PCR or culture-based techniques) from the wild type *Salmonella* because of its loss of function *phoN* mutation. The surrogate strain was shown to be avirulent in two animal models.

The research focused only on specialty crops (tomatoes, leafy greens and cantaloupes). The CPS staff is in constant communication with both the California industry and the scientists working on this project, and ensures that no other commodities are benefited from this project other than specialty crops.

Members of the Principal Investigator's (PI)'s group developed genetic tools for manipulation of *Salmonella*, constructed individual avirulent strains and the final surrogate, carried out studies associated with attachment of the strains to abiotic surfaces, persistence in tomatoes and well water. Mouse infections were also carried out at University of Florida (UF). The co-PI at University of California, Irvine carried out studies that defined *Salmonella* virulence genes and identified those that were critical for persistence in tomatoes; also, this co-PI developed libraries of *Salmonella* mutations that were used to engineer the final avirulent construct, and provided guidance for animal experiments. The Co-PI at UF Lake Alfred Research and Education Center carried out experiments on persistence of the avirulent strains in water, soils and in association with leafy greens.

Goals and Outcomes Achieved

Mutant construction: One-step PCR mutagenesis was used to replace entire SPIs with *frt-kan-frt* cassettes. Subsequently, the antibiotic markers were removed. This approach allowed us to precisely excise entire pathogenicity islands, leaving only a ~20-nucleotide "scar" in place of each pathogenicity island. The *phoN* gene was removed similarly. Excisions were confirmed by PCR in Attachment # 1, Fig. 1. Once mutants were constructed, all were first tested on Congo red plates to check for the *rdar* phenotype, and if deviations from the expected phenotype were observed, mutants were remade prior to phenotypic characterization.

Even though a strain of *S.* Typhimurium lacking its virulence plasmid pSLT was already constructed and was shown to have no fitness defect in tomatoes, the project team designed and constructed a strain lacking the pSLT plasmid in the same background as the rest of the mutations. This was done to ensure that all mutations were in the same background.

Animal virulence studies: Mutations in any of the *Salmonella* Pathogenicity Islands reduce virulence of the pathogen in animal models. Therefore, it was expected that the strain lacking all these mutations will be avirulent. The project team tested virulence of the strain in two murine models (female BALB/c, most commonly used for *Salmonella* infections, and black C57BL/6, most commonly used to model human disease). Mice were infected by oral gavage, animals were observed for a week, and *Salmonella* cells were recovered from liver, spleen, intestine and Peyer's patches (lymphatic tissue in the small intestine invaded by *Salmonella* when it crosses the intestinal barrier) on a selective medium. As expected, the surrogate strain was fully avirulent, and no *Salmonella* was recovered from any of the organs of mice infected with the surrogate strain (Table 1). The surrogate strain was fully avirulent in mice: even at doses that exceed wild type LD50 by tenfold, the surrogate did not cause a disease in mice, please see (Attachment # 1, Table 2).

Culture-based detection of the surrogate: It would significantly streamline the identification of the surrogate if the project team can engineer it to behave just like the wild type under all environmental conditions, but display a somewhat different phenotype on detection media. Engineering the surrogate to contain a fluorescent protein or an antibiotic resistance marker is un-acceptable to environmental health and safety offices. The use of mercury resistance was approved for human volunteer studies with *Vibrio cholerae* vaccine strains, and the *mer* Hg-resistance operon could be similarly used to mark *Salmonella* surrogate strains. However, the tightening regulation of mercury use and disposal of Hg-containing wastes may mean that this would not be the optimal way to mark the surrogates. Instead, the project team used a *phoN* (an alkaline phosphatase) mutant for such a purpose. The *phoN* mutants are unable to use the chromogenic substrate XP (5-bromo-4-chloro-3-indolylphosphate). This mutant was moved into the surrogate strain. Because the *phoN* mutation resulted in a loss of function, it is expected that this method to mark the surrogate will be broadly acceptable to Environmental, Health, and Safety (EHS) boards.

As shown in Attachment #1, Fig. 2, the *phoN* mutant behaves just like the wild type *Salmonella* on XLD by forming black colonies. (XLD is the medium that is used most commonly for the isolation of *Salmonella*.) However, as shown on the right image, it can be easily distinguished from the wild type on a secondary plate containing a substrate for phosphatase. This is a loss-of-function mutant, and therefore it allows for identification of the surrogate strain without using any foreign markers.

PCR-based detection of the surrogates: Because the mutant strain lacks SPI-1, it will not be detectable using common primers for *Salmonella* detection (which target *hilA* or *inv* genes present in SPI-1). This is demonstrated in Attachment #1, Fig. 3.

Attachment of the avirulent strains to surfaces and their responses to common sanitizers under laboratory conditions & Attachment to abiotic surfaces: Biofilm assays were performed on polystyrene and polypropylene surfaces. The ability of the bacteria to form biofilms was estimated using crystal violet following a 24-h incubation at 22°C. The SPI-1 mutation (and to a lesser extent the SPI-4) mutations appear to have increased biofilm formation by the surrogate strain (Attachment #1, Fig. 4). The increase in biofilm formation on polystyrene is not statistically significant compared to the wild type, however, the increase in biofilm formation on polypropylene is about 2.5 fold.

Attachment to leafy greens: The constructed avirulent strains and their wild type parents were inoculated onto plant surfaces and persistence of the surrogate strain, individual avirulent mutants and the wild type were tested on cut romaine leaves at 4°C and 10°C. It appears that the SPI-2 mutant was less fit on cut romaine leaves; however, the rest of the mutations in the final surrogate strain were statistically not distinct from the wild type Attachment #1 in (Table 3, 4; Fig. 4, 5).

Persistence in red and green tomatoes: Shallow wounds in tomato surfaces were seeded with ~100–1,000 cells of each mutant. Fruits of three tomato varieties grown in the field under conventional production conditions were tested in for these experiments. Tomatoes supplied by an industry partner as well as store-bought tomatoes “Campari” were tested. Inoculated tomatoes were incubated at 18 to 21°C. *Salmonella* were recovered from internal tissues at the end of a one week-long incubation period. Infected produce was macerated by stomaching in PBS and dilution-plated on a selective XLD medium. Even though differences between persistence of individual mutants in tomatoes were not strong (Attachment # 1, Fig. 6), the final surrogate strain was approximately 10-fold less fit than the wild type in tomatoes (Attachment #1, Fig. 7).

Sensitivity to common chemicals and chlorine: To establish how deletion of virulence genes affects susceptibility to common chemicals in the post-harvest environment, the wild type strain and an avirulent strain MHM56 lacking SPIs were inoculated onto cantaloupes, and then exposed to a variety of post-harvest treatments (Attachment #1, Fig. 8). For ease of the detection, a wild type strain was marked with a kanamycin-resistance cassette in a neutral site, resulting in CEC1000. Survivability studies in response to post-harvest treatment with 200 ppm chlorine and two commercial produce washes were conducted with spot-inoculations using previously developed protocols either directly or with slight modifications. Experiments presented in Attachment #1, Fig. 6 were carried out at UF in collaboration with a commercial partner.

Generally, the wild type and the surrogate strain responded similarly to the surface disinfection treatments commonly used in the industry.

Testing the field fitness of the surrogate strains in soil and irrigation water. Even though there were differences between individual mutants in terms of persistence in untreated well water and Environmental Protection Agency (EPA) worst-case water, wild type and the surrogate were indistinguishable throughout the duration of the 3-week experiment (Attachment #1, Fig. 9, 10; Table 5). When tested for persistence in tap water and in water from a highly eutrophied body of water, both the wild type and surrogate *Salmonella* strains were non-detectable following 2–6 hours of incubation. It appears there is significant variability in survival of the avirulent mutants in soils. For the first 14 days, persistence of the surrogate in soil was statistically indistinguishable from the wild type; however, populations of the surrogate declined rapidly by day 22 (see Attachment #1, Fig. 11, Table 6). The project team is uncertain what the basis is for this phenotype, but these observations indicate that in non-sterile soils, the surrogate faithfully represents the wild type for at least 14 days.

This project was designed to provide deliverables within the 2 years. This surrogate strain can now be used for on-site experiments, once appropriate regulatory approvals are in place. Testing of the surrogate strain was completed under a range of conditions, all in various levels of containment; fitness of this strain was tested in irrigation water, in pond water, in two different soils and in/on vegetables. The team also constructed a cantaloupe decontamination conveyor in containment, and used the surrogate strain on cantaloupes to test a number of common surface disinfection procedures. These experiments required only institutional approval, and are now completed. Use of this strain at other academic locations will require approvals of individual institutional review boards (IRBs), and each institution will do that on a case-by-case basis. The team has already shared the surrogate strain with academic labs at UC Davis and University of Florida Citrus Research and Education Center, and are conducting field and on-site experiments. Approvals needed for producers to use the surrogate strain on-site at other (non-academic) locations is a separate issue, and not part of this study.

The entire study will be submitted for peer review and once the peer review process is completed and the study is published (estimated February 2016), this strain will be available to all interested entities who have the appropriate approvals to work with the organism and test it under the conditions that are approved either by their IRBs or other agencies.

The team set out to develop a surrogate avirulent *Salmonella* strain suitable for field studies. This strain was constructed and its behavior was compared to that of the wild type strains. Deleting over 100,000 bp of DNA was not expected to be completely harmless to *Salmonella*. However, in general, the phenotypes of the avirulent strain correlated reasonably well with those of the wild type.

Prior to this project, there were no truly avirulent *Salmonella* strains suitable for on-site studies, therefore this project in essence was creating the baseline data for this study. This project addressed this need and developed a construct suitable for on-site studies under FSMA. As indicated above, each presented experiment provided the foundation for the next step of the project, ultimately leading to the construction and validation of the avirulent surrogate *Salmonella* strain.

Development of the avirulent *Salmonella* surrogate suitable for on-site study is the main important outcome of this study. Pathogenicity islands were cleanly excised, the strain does not carry virulence or any other plasmids, and the strain does not have any antibiotic resistance markers.

Beneficiaries

Under FSMA rules, states can apply for variances from FSMA regulation and individual farms/producers can apply for alternatives to FSMA regulations. In both cases, on-site validation of the protocols will be required. This avirulent strain will be broadly useful to state and industry scientists who are working on developing such variances and alternatives, which will ultimately benefit specialty crop producers.

The potential economic impact could be significant (estimate: at least $6,000,000 in losses from Salmonella-related, produce-borne outbreaks to the economy in terms of hospital bills, lost wages, lost income, and lost sales). This project will allow for the development of approaches for ensuring microbiological food safety that are uniquely adapted to a particular environment or situation. According to the most recent (2012) Census of Agriculture there are 42,729 farms that grow specialty crops (including tomatoes, leafy greens, and melons) in California, representing $23.9 billion in sales in the state (http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Rankings_of_Market_Value/California/index.asp). More specifically, the beneficiaries of this project in California include the 250 growers of fresh-market tomatoes and the 55 melon growers and 35 melon grower/handlers in the state.

The PI from the University of Florida presented final research results in June at the 2015 CPS Produce Research Symposium in Atlanta, GA. Interim results were presented previously at the 2014 CPS Produce Research Symposium in Newport Beach, CA. Both symposia had approximately 245 attendees. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academics, produce industry representatives, and members of regulatory agencies. The annual symposium provides expert panels to critique the research results after presentation by the researcher, which helps participants evaluate how the results can be used in their respective businesses.

Project results will be disseminated at industry meetings, and streamed through social media sources. Results also will be made available online as follows:

1. Final reports submitted to CPS (after the June 2015 symposium) will be posted on the CPS website: http://www.centerforproducesafety.org/grant_opportunities_awards.php

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The following websites provide additional resources on the final reports and symposium proceedings:

Center for Produce Safety: http://www.centerforproducesafety.org/resources.php
Produce Marketing Association: http://pma.com
Western Growers Association: http://www.wga.com/

Lessons Learned

Because the project team has shown that individual *Salmonella* virulence genes are not involved in persistence within tomatoes, it is anticipated that deleting all virulence genes and removing the virulence plasmid would not affect phenotypes associated with persistence in pre- and post-harvest environment. However, as is clear from the data, combining five large mutations with removing the virulence plasmid had an impact on some of the phenotypes associated with biofilm formation and persistence in soils and tomatoes. Nevertheless, the effect of the mutations is not very dramatic. The project team envisioned that this strain could be used for some on-site studies, and tests of a variety of conditions revealed that it could be quite useful for testing persistence of the pathogen in water, for surface disinfection studies and in tests with leafy greens. As other scientists test this surrogate strain under other conditions, it will broaden potential uses of this construct.

This avirulent surrogate *Salmonella* strain will be broadly useful for industry, states and also academic scientists, as it will allow work on FSMA regulations and work with the avirulent *Salmonella* in less stringently monitored facilities.

Additional Information

See below for Publications and Presentations; see Attachment #1 for Figures and Tables.

Publications:

1. Moraes, M., Danyluk, M., McClelland, M, Teplitski, M. *Salmonella* surrogate strain suitable for field release studies. *In preparation*
2. Brandl, M.T, Cox, C.E., Teplitski, M. 2013. *Salmonella* interactions with plants and their associated microbiota. *Phytopathology* 103: 316-325
3. Marvasi, M., Cox, C.E., Xu, Y., Noel, J. , Giovannoni, J., Teplitski, M. 2013. Differential regulation of *Salmonella* Typhimurium genes involved in O-antigen capsule production and their role in persistence within tomatoes. *Mol Plant Microbe Interact.* 26: 793-800.

Presentations:

1. Teplitski, M. *Salmonella* interactions with crop plants: mechanisms and practical consequences. Food Science and Human Nutrition Department, University of Florida. Feb 10, 2015. Gainesville, FL
2. Moraes, M.H., McClelland, M., Teplitski, M. 2014. Mutant library screening reveals that *Salmonella* virulence genes are involved in the interactions with tomatoes. Southeastern Microbiology Summit – Joint Meeting of Southeastern and Florida Branches of ASM, Ponte Vedra, FL, September 5-7, 2014.
3. Salas Gonzalez, I., Moraes, M.H., Teplitski, M. 2014. Comparative genomic analysis of *Salmonella enterica* sv Newport and a common generalist *S. enterica* sv Typhimurium. Southeastern Microbiology Summit – Joint Meeting of Southeastern and Florida Branches of ASM, Ponte Vedra, FL, September 5-7, 2014.

4. Farias, M., Jenkins, K., Marvasi, M., Teplitski, M. 2014. Contribution of the *Salmonella* capsular transcriptional regulators *rcsA* and *rcsB* to the persistence of *Salmonella* in tomatoes. Southeastern Microbiology Summit – Joint Meeting of Southeastern and Florida Branches of ASM, Ponte Vedra, FL, September 5-7, 2014.
5. Kirkpatrick, E., Marvasi, M., Teplitski, M. 2014. A carnitine metabolism key gene is involved in *Salmonella* persistence within tomatoes. Southeastern Microbiology Summit – Joint Meeting of Southeastern and Florida Branches of ASM, Ponte Vedra, FL, September 5-7, 2014.
6. Teplitski, M. 2014. Avirulent *Salmonella* strains and their use to model behavior of the pathogen in water, composts, in and on vegetables. Center for Produce Safety Research Symposium, Newport Beach, CA. June 25, 2014
7. Farias, M., Jenkins, K., Marvasi, M., Teplitski, M. 2014. Contribution of the *Salmonella* capsular transcriptional regulators *rcsA* and *rcsB* to the persistence within tomatoes. Florida Association for Food Protection Annual Educational Conference, Clearwater Beach, FL, May 28-30, 2014.
8. Salas Gonzalez, I., Moraes, M.H., Teplitski, M. 2014. Comparative genomic analysis of *Salmonella enterica* sv. Newport Type 3 (prevalent in tomatoes) and a common generalist *S. enterica* sv. Typhimurium. Florida Association for Food Protection Annual Educational Conference, Clearwater Beach, FL, May 28-30, 2014.
9. Moraes, M.H., Teplitski, M. 2014. The role of *Salmonella enterica* virulence determinants in its proliferation in tomato fruits. Florida Association for Food Protection Annual Educational Conference, Clearwater Beach, FL, May 28-30, 2014.
10. Parker, K., Moraes, M.H., Teplitski, M. 2014. The effect of *Salmonella* Pathogenicity Islands on biofilm formation. Florida Association for Food Protection Annual Educational Conference, Clearwater Beach, FL, May 28-30, 2014.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 65	Project Title: Genomic elucidation of the physiological state of enteric pathogens on pre-harvest lettuce	
Grant Recipient: UC Regents, Center for Produce Safety	**Grant Agreement No.:** SCB12065	**Date Submitted:** December 2015
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** 530-757-5777	**Email:** bonnie@centerforproducesafety.org

Project Summary

Contamination of produce with enteric pathogens can occur in the pre-harvest environment, and many produce-associated outbreaks have been traced back to the pre-harvest environment. Once contamination of produce in the field occurs, the enteric foodborne pathogens enterohemorrhagic *E. coli* (EHEC) and *Salmonella* are capable of surviving on the plant surface over long periods of time, yet little is known about the physiological state of the pathogen in this environment or how pre-harvest environmental factors influence the physiological state. Understanding the physiological state of foodborne pathogens is important as it can affect the ability of the pathogens to (i) survive post-processing decontamination procedures, such as a chlorine wash, and (ii) survive and cause disease in the host (for example, physiological state may affect the ability of a pathogen to survive gastric acidity). The physiological state of enteric pathogens on pre-harvest produce can also significantly impact the ability to detect these pathogens in this environment. A better understanding of the physiology of enteric pathogens thus provides an opportunity to develop improved interventions and detection methods for these important pathogens.

Enterohemorrhagic *E. coli* (EHEC) and *Salmonella* are two key pathogens of importance in the produce industry; both have been shown to be responsible for produce recalls as well as produce-associated foodborne disease outbreaks. A better understanding of the physiology of these organisms on leafy greens under different environmental conditions provides a unique opportunity to develop and validate interventions, to develop new detection methods, and to ensure that interventions and detection methods are effective with bacteria found in the physiological state one would expect on leafy greens in typical pre-harvest environmental conditions. In this project the complete RNA found in bacterial cells was specifically characterized to provide a comprehensive picture of the physiology of the bacteria. This project is particularly timely since (i) comprehensive characterization of the physiological state of diverse pathogens has recently become feasible and affordable through the development of "RNA-sequencing" technologies, and (ii) new RNA-based pathogen detection methods have become commercially available, providing a pathway for commercial translation of the research findings.

This project did not build on a previously funded Specialty Crop Block Grant Program (SCBGP) project.

Project Approach

Key activities and tasks that were performed include (i) selection of four EHEC and four *Salmonella* strains for the project; (ii) cultivation of lettuce plants and inoculation of plants with the four EHEC and four *Salmonella* strains, followed by incubation under different environmental conditions mimicking conditions typical for different harvest times in the Salinas Valley; (iii) characterization of EHEC and *Salmonella* survival under these different conditions; (iv) characterization of the physiological state of EHEC and

Salmonella on the lettuce plants (using RNA sequencing); and (v) characterization of the ability of EHEC and *Salmonella* under different physiological conditions to survive exposure to chlorine washes.

Key results from this grant include (i) identification of considerable variation in survival on lettuce plants for EHEC and *Salmonella* strains of the same serotype; (ii) data supporting that for at least some EHEC strains, bacteria that have adapted to lettuce for >3 days show increased chlorine survival (see Figure in attachment); and (iii) comprehensive RNA sequencing data describing the physiology of EHEC and *Salmonella* on lettuce plants grown under different environmental conditions.

Key recommendations based on these findings include the following:

- Evaluation and validation of post-harvest pathogen interventions for leafy greens should use pathogen strains that have been adapted to the leafy green environment for at least 3 days.
- The data show that both strain and environment can have a significant impact on physiological state, suggesting that further work is needed to determine how strains and pre-growth conditions should be selected for challenge studies and evaluation of interventions.
- Genes that show consistent high transcript levels on lettuce should be further pursued as potential targets for mRNA-based detection systems, which may provide significant advantages over traditional DNA-based methods as (i) mRNA is found at a higher level than DNA in a given cell, thus allowing for more sensitive detection in a shorter time frame, and (ii) mRNA is rapidly degraded in a dead bacterial cell.

The project would not benefit other commodities as the physiological state of *Salmonella* and EHEC grown on lettuce was specifically characterized. The CPS staff is in constant communication with both the California industry and the scientists working on this project, to ensure the project is solely enhancing the competitiveness of specialty crops.

The project Principal Investigator (PI) at Cornell University oversaw and coordinated the project. The co-PI at North Dakota State (NDSU) conceived the project with the PI while at Cornell, and subsequently moved to NDSU as a professor; NDSU provided appropriate growth chamber facilities for the project, and all work requiring growth chamber facilities that allowed pathogen inoculation studies was performed at NDSU.

Goals and Outcomes Achieved

Activities that were completed include (i) selection of four EHEC and four *Salmonella* strains for inclusion in the project; (ii) characterization of EHEC and *Salmonella* survival on lettuce plants under different environmental conditions; (iii) characterization of the physiological state of EHEC and *Salmonella* on the lettuce plants (using RNA sequencing); and (iv) characterization of the ability of EHEC and *Salmonella* under different physiological conditions to survive exposure to chlorine washes. These activities provided comprehensive molecular data on the physiological state of enteric pathogens on pre-harvest produce, a key benchmark identified in the original proposal. The PI attended the 2014 CPS Produce Research Symposium and will present project results at the 2015 CPS Produce Research Symposium in another project objective.

Outcome measures set out for the project were citations of publications as well as processor implementation of recommendations, and use of these data by companies and others that develop detection methods for foodborne pathogens in produce. Publications were submitted to peer-reviewed journals. Actual RNA-sequencing data from this project will be made publically available through the Sequence Read Archive at NCBI http://www.ncbi.nlm.nih.gov/sra so that they are readily accessible by companies and others that develop detection methods within the industry.

One of the main project objectives was to test one strain of each EHEC O157:H7, EHEC O26:H11, *Salmonella* Newport, and *Salmonella* Typhimurium, under four different harvest season conditions. Initial experiments with multiple strains of each serotype highlighted that considerable variation in survival on lettuce plants can occur for strains of the same serotype. Based on these data, the plan was modified to include two strains of each serotype (for a total of eight strains) and to focus on environmental conditions representing the two harvest seasons that show the largest differences in climatological conditions. This modification resulted in a more in-depth set of data for each season tested and allowed for an evaluation of the importance of environmental condition and strain on pre-harvest survival and physiological state on lettuce. The project activities and overall plans were revised to change the proposed work from measuring acid resistance of EHEC and *Salmonella* inoculated onto lettuce, to specifically assessing the expression of acid resistance genes in EHEC and *Salmonella* inoculated onto lettuce; as a result, specific information on the potential impact of growth on lettuce on acid resistance was collected. Other than those modifications, the main goals established were achieved.

Key baseline data that has been gathered for this project include (i) survival data for EHEC and *Salmonella* strains, indicating considerable variation in survival on lettuce plants for strains of the same serotype; (ii) chlorine wash survival data for EHEC and *Salmonella* grown on lettuce plants under different environmental conditions, indicating that longer incubation on lettuce can lead to greater chlorine survival, at least for one EHEC strain that had been associated with a produce-related outbreak; and (iii) comprehensive RNA sequencing data describing the physiology of EHEC and *Salmonella* on lettuce plants grown under different environmental conditions, indicating that the pathogens are experiencing osmotic stress, oxidative stress, and cell envelope stress while on the lettuce plants.

Major successful outcomes of the project are (i) collection of quantitative data for survival of four EHEC and four *Salmonella* strains on lettuce exposed to different environmental conditions; (ii) chlorine wash survival data for four EHEC and four *Salmonella* strains grown on lettuce plants under different environmental conditions; (iii) RNA-seq data characterizing the physiology of four EHEC and four *Salmonella* strains on lettuce exposed to different environmental conditions (a total of >225,000,000 sequence reads, which will be publically available in the Sequence Read Archive repository hosted by NCBI, link mentioned above. These data can be used in the future to identify specific genes for use in RNA-based pathogen detection strategies in the produce industry.

Beneficiaries

Key beneficiaries of these data are (i) produce processors, (ii) companies that develop pathogen tests for use in the produce industry, and (iii) other scientists. Specifically, produce processors will benefit from this research as it indicates the importance of using pathogen strains that are appropriately adapted to produce environments when validating the effectiveness of decontamination treatments, thus providing for more reliable interventions, which reduces the recall risk. The produce industry at large will also benefit from this project as it provides a large publicly available library of RNA-sequencing data that characterizes the physiological state of two key pathogens, EHEC and *Salmonella*, on produce, which will be a resource for development of improved intervention and detection methods.

According to the most recent (2012) Census of Agriculture there are 42,729 farms of specialty crop growers representing $23.9 billion in sales in the state of California (http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Rankings_of_Market_Value/California/index.asp).

Prevention of one recall every 2 years through improved validation would likely translate, at a minimum, into an economic benefit of cost savings of $500,000/year. The estimated total recall costs of $1 million per recall is a low estimate and is based on recent U.S. data that indicate that 52% of food recalls each cost $10 million or more, while 48% of food recalls cost less than $10 million (http://www.gmaonline.org/file-manager/images/gmapublications/Capturing_Recall_Costs_GMA_Whitepaper_FINAL.pdf)

The potential economic impact from this project will come from either (i) improved validation of interventions by using pathogen strains adapted to lettuce, thus reducing the likelihood of recalls (and associated recall costs), or (ii) more rapid detection through use of mRNA-based targets, which will reduce the time to results and hence provide associated economic benefits (e.g., shorter storage time; more rapid release and shipping of products).

PI from Cornell University, presented final research results in June at the 2015 CPS Produce Research Symposium in Atlanta, GA. Interim results were presented previously at the 2014 CPS Produce Research Symposium in Newport Beach, CA. Both symposia had approximately 245 attendees. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academics, produce industry representatives, and members of regulatory agencies. The annual symposium provides expert panels to critique the research results after presentation by the researcher, which helps participants evaluate how the results can be used in their respective businesses.

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The following websites provide additional resources on the final reports and symposium proceedings:

- Center for Produce Safety: http://www.centerforproducesafety.org/resources.php
- Produce Marketing Association: http://pma.com
- Western Growers Association: http://www.wga.com/

Lessons Learned

Key lessons learned from the project include that (i) different strains within the same EHEC or *Salmonella* serotype can show considerable variation in survival on lettuce plants, (ii) validation studies on post-harvest interventions, specifically chlorine washes, may not correctly estimate the effectiveness of these washes unless challenge strains have adapted to lettuce for at least 3 days, and (iii) that EHEC and *Salmonella* are experiencing osmotic and oxidative stress while on the lettuce plants, as indicated by increased expression of genes involved in these stress responses. The data show that both strain and environment can have a significant impact on physiological state, which suggests that further work is needed to determine how strains and pre-growth conditions should be selected for challenge studies and evaluation of interventions for foodborne pathogens in produce.

It was surprising to find that chlorine survival was improved for the O157:H7 strain from the 2006 spinach outbreak after this strain was adapted to lettuce for 3 and 5 days when implanting this project.

The project timeline for activities and overall plans had to be revised to change the proposed work from measuring acid resistance of EHEC and *Salmonella* inoculated onto lettuce to specifically assessing the expression of acid resistance genes in EHEC and *Salmonella* inoculated onto lettuce. Part of the challenge that led to the need for this change was getting access to plant growth chambers that allow for controlled environmental conditions and permit the use of disease causing agents that are classified as biosecurity level 2 (BSL-2). Any future projects that will need these types of growth chambers would have to take this issue into account.

While it was expected that RNA-sequencing would provide for sensitive and comprehensive characterization of the physiological state of EHEC and *Salmonella* on lettuce, it was surprising how much in-depth data could be generated at the relatively modest cost for sequencing. While microarrays have previously been used as a tool to characterize the physiological state of bacteria, RNA-seq provides for more comprehensive and affordable data collection and should be used in all future experiments with this type of approach. Another key lesson from this project was the need for appropriate and sufficient growth chamber infrastructure, as detailed above.

Additional Information

See Attachment #1 for Figure showing chlorine survival for different EHEC strains after 1, 3, and 5 days of inoculation is provided in the attachment.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 66	**Project Title:** Practical validation of surface pasteurization of netted melons	
Grant Recipient: The Regents of the University of California, Davis, Center for Produce Safety (CPS)	**Grant Agreement No.:** SCB12066	**Date Submitted:** December 2015
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** (530) 757-5777	**Email:** bonnie@centerforproducesafety.org

Project Summary

No one wants to take cantaloupes off the shelf or foodservice menu offerings. Since 1990, cantaloupes have been associated with 36 outbreaks and pathogen-based recalls recorded in the public health database. Preventive controls are viewed as the best strategy to combat this burden on consumers, public health, and the general economy, as well as the sustainability of this important fruit category. The essential functionality of thermal surface-pasteurization of netted melons has been recognized at the basic and applied research level for over a decade, primarily as hot water immersion and hot water brush-washing. The reported inactivation of inoculated pathogens, predominantly *Salmonella enterica* serotypes, has exceeded a 4.5 log reduction. Despite this evidence, commercial adoption by primary packers of the whole, raw commodity has been limited largely by cost and a limited compelling motivation. Various hot water brushing and steam pasteurization technologies have been commercially installed at off-shore netted melon shipping points and in a few domestic fresh-cut processor facilities.

With the recurring economic losses and human tragedy associated with the most recent outbreaks during 2011 and 2012, this time involving *Listeria monocytogenes* (*L. monocytogenes)* and *Salmonella enterica* serotypes (Typhimurium and Newport) on domestic cantaloupe produced in Colorado and Indiana, grower-shippers in the California cantaloupe industry asked CPS to evaluate a 'hot-wash' process that was in the news. Project staff sought to assist in converting these reported bench-top studies to a validated and verified high-throughput commercial system across extended seasons, growing districts, varieties, netted rind traits, and other commercial variables.

This project met the criteria of importance and timeliness to the sustainability and competitiveness of not only the California cantaloupe industry, but also cantaloupe as a valued source of nutrition and enjoyment for consumers. The acute response to the tragic 2011 *L. monocytogenes* outbreak on cantaloupe, originating in Colorado, and subsequent aftermath in the months that followed, was a call by foodservice and supermarket retailers for evidence of food safety programs and postharvest treatments to assure freedom from foodborne outbreaks. Driven by press releases and a desire by major cantaloupe grower-shippers to provide this assurance, plans were drawn in late 2011 for new cantaloupe wash systems based on hot water immersion. Based on CPS studies conducted several years earlier, project staff recognized that any thermal pasteurization process for whole retail-marketed cantaloupe would need a far more detailed and comprehensive foundation in validation research, as well as establishment of a set of process control verification criteria to be commercially functional and accepted by state and federal public health agencies. Following contact from these cantaloupe shippers, project staff rapidly developed a project proposal to collect this data and, ultimately, disseminate it in public forums. By subjecting the design and implementation of these thermal-wash cantaloupe disinfection systems to a higher level of objective science-based approaches, largely within a commercial setting, project staff were able to significantly influence the positive potential while defining the practical realities and limitations of the technology, as presented in the existing publications and popular press expectations.

Although not directly built on a previous Specialty Crop Block Grant Program (SCBGP) project, studies in California on cantaloupe food safety funded by CPS substantially influenced the approach of project staff to addressing the experimental design for validation and verification research on this project. Specifically, the limited survival of *Salmonella* in research trials associated with project *Risk assessment of Salmonella preharvest internalization in relation to irrigation water quality standards for melons and other cucurbits* (2011-2012) and the absence of detection of *Salmonella* and *L. monocytogenes* in the rapid response project *On-farm Evaluation of the Prevalence of Human Enteric Bacterial Pathogens During the Production of Melons in California* (2012) were compelling in the expectation that the thermal-wash process would not have to achieve a standard 5-log reduction of pathogens, as their prevalence and abundance normally on California cantaloupes was very limited (undetectable at practical routine sampling regimes). Rather, CPS field studies of natural populations indicated that the best challenge inoculum was desiccation-stress adapted cells in low numbers on the netted rind. Not insignificantly, CPS' prior work on these and related cantaloupe food safety issues developed the confidence for commercial grower-shippers to work with CPS in a largely open and iterative fashion on a sensitive project.

Project Approach

The proposed project research plan was to develop 'real-world' data for this postharvest disinfection treatment to arrive at a balance in which food safety objectives do not compromise quality and arrive at a set of best practice options for the industry. To achieve this goal, experimental farm trials were planned using an attenuated isolate of *Salmonella typhimurium* and *Listeria innocua* (*L. innocua*), a surrogate for *L. monocytogenes*, and were conducted at the University of California, Davis (UC Davis) Research Farm Facility. Fruit from these open environment trials were subjected to hot water surface-pasteurization alone or in combination with a sequentially applied labeled disinfectant to achieve at least a 4-log reduction of applied pathogen surrogates and to retain or improve fruit shelf-keeping properties. The recognized scarcity of detectable populations of pathogens, such as *Salmonella*, on cantaloupe in arid western production regions essentially precludes verification of hot water pasteurization with non-inoculated fruit in either a lab pilot system or commercial system. Based on experience from prior CPS studies, project staff targeted log reduction of indigenous total Coliform as the appropriate benchmark for future commercial verification studies on-site that can be correlated with 4-log reductions of stress-adapted inoculated strains from model studies at time:temperature regimes that both define and parallel the commercial process design and operational parameters. Therefore, hot water surface-pasteurization alone or in combination with a sequentially applied labeled disinfectant in the twin commercial process systems was to be verified to both achieve a regional and temporally reproducible success criterion of at least a 2-log reduction of indigenous total Coliform on netted melon rind and retain or improve fruit shelf-keeping properties. The outcomes of this research project will be very valuable for the cantaloupe industry and template standard operating procedures (SOPs) should be extendable to other types of melons and durable fresh produce. Project staff believe that a public information resource of this disinfection technology may be scalable, easily transferred, and successfully implemented by the global cantaloupe and netted melon supply and fresh processing industry.

The key accomplishments of the activities and tasks include the following:

- Validation studies with inoculated cantaloupe defined the non-injurious treatment 'window' (time:temperature) for thermal pasteurization of cantaloupe rind with five different varieties. Using standard lab methods for these studies, a 3.5- to 4-log reduction in recoverable applied pathogens was observed following different treatment regimes. The ideal lab validation of projected practical and achievable commercial conditions was determined to be 70°C for 45 seconds.
- Validation studies comparing true pathogens with surrogate non-pathogens in heated water and in hot water washes, with or without preceding or subsequent sprays of 30–80 parts per million (ppm) peroxyacetic acid (PAA) showed highly similar outcomes. In this manner, project staff were able to anticipate reasonably valid predicted outcomes from limited containment field survival studies and pilot thermal-wash studies, neither of which is allowed to be conducted with true human pathogens.
- Validation studies demonstrated that passage of inoculated cantaloupe in a PAA fogging tunnel would be unlikely to achieve more than a 1-log reduction and had no significant effect on natural bacteria levels on the rind. This outcome convinced the project's industry cooperators to invest more priority in a robust thermal-shower delivery system for primary disinfection and retain the PAA treatment, desired in general by the industry for better mold control rather than chlorine, for a sequential axillary spray.
- Comparison of the open-field survival of the surrogate *Salmonella* and *Listeria* helped confirm project staff's expectations of a limited survival following a mock-irrigation contamination and created the 'contaminated' fruit for the project's model thermal-shower efficacy studies. To assess survival in the field, two replicated experiments of 45 melons per pathogen surrogate were spot-inoculated with 100 µl of 8-log CFU/ml *Salmonella typhimurium* (PTVS 337) and *L. innocua* (TVS 451) in two separate 10-cm diameter circles ($A = 19.63\ cm^2$). At 24 hours, 4 days, 7 days and 14 days post-inoculation, 10 melons were removed from the field and the inoculated circles from each melon were removed with a sterile knife, homogenized, and plated on CHROM *Salmonella*+rif or CHROM *Listeria*+rif, respectively, following incubation at 37°C for 24 hours and 48 hours. If samples were not quantifiable (no characteristic colony growth), 10 ml 2X buffered peptone water (BPW)+rif or 2X *Listeria* enrichment broth (LEB)+rif were added to the appropriate sample bags with wash buffer and the original rind disc, and incubated at 37°C for 24 hours and 48 hours, respectively. Aliquots of these enrichment cultures were spot-plated on CHROM *Salmonella*+rif and CHROM *Listeria*+rif for detection. A similar 5-log reduction in survival was observed in two trials with 7 days of inoculation, but 30–50% of fruit had surviving populations at 14 days in the field.
- A set of verification criteria for rind surfaces and re-circulating heated water were developed based on Year 1 outcomes from combined lab enumeration studies of field harvested cantaloupe subjected to wash water temperatures of unwashed, 55, 60, 65, 70, 75, 80, and 95°C for varying contact times. Consistent with the designed capacity of the commercial systems, most studies standardized disinfection efficacy and quality effects at 45 seconds. Although several naturally abundant indicator and index bacterial groups were tested, based on thermal tolerance level, project staff determined that a 2-log reduction of total Enterobacteriaceae would give the greatest predictive association with pathogen reduction expectations.
- In the course of on-site studies at the commercial operation, project staff demonstrated that populations on cantaloupe rinds decreased significantly ($P < 0.05$) following a 65°C thermal-shower wash and sequential 50 ppm PAA spray compared to incoming melons, with average reductions of

1.54, 2.09, and 1.93 log CFU/cm^2 for total heterotrophic bacteria, total coliforms, and Enterobacteriaceae, respectively.

- Microbial populations in both the thermal-shower tunnel and recirculation tank water were statistically similar ($P > 0.05$) throughout daily wash-pack operations, ranging from 1.44–2.53 log MPN(most probable number)/100 ml for total coliforms, *Escherichia coli (E. coli)*, and Enterobacteriaceae. This outcome demonstrated that the enhanced filtration and flash-heating loop, implemented after Year 1 studies, were effective in limiting bacterial load accumulation during a daily pack-out of thousands of cantaloupe entering the wash system.

This project focused solely on cantaloupe disinfection and quality retention. The validation studies and development of verification criteria will benefit other produce commodities by extension, but project work only directly addressed and utilized cantaloupe.

The project's two main industry partners significantly contributed to the execution of project objectives. BioSafe Systems contributed in-kind support for the equipment used for conducting studies with PAA and PAA-fogging applications. The primary grower-shipper and the main seed supplier for that grower-shipper were instrumental in facilitating many CPS laboratory studies for this project, but especially and critically all on-site evaluations over the two-year program.

Goals and Outcomes Achieved

The activities that were completed in order to achieve the performance goals and measurable outcomes include the following:

- *Design and construction of model prototypes and preliminary tests*- A recirculating heated wash system consisting of a 0.61 × 0.61 × 0.46 m sink, thermally protected centrifugal pump, Hot Tap Pro 100 water heater, and perforated shower-manifold, consisting of a parallel array of three polyvinyl chloride pipes was used for laboratory-scale experiments. Five noninoculated or inoculated melons each were either: 1) washed for 45 seconds with 63–68°C water; 2) pressure sprayed for one second, adequate for full coverage of the inoculated spots, with 30 ppm PAA; 3) washed for 45 seconds with 63–68°C water followed by a one second pressure spray with 30 ppm PAA; or 4) retained without water contact to determine initial populations of bacteria.
- *Evaluate the quantitative and qualitative survival of attenuated S. enterica and L. innocua during cantaloupe open field production*- For thermal ± antimicrobial rind pasteurization studies using field-inoculated cantaloupe, replicates of individual fruit near harvest maturity were similarly spot-inoculated on the upper rind-surface at dusk to allow inoculum to dry with limited negative impact of solar-UV inactivation. Using this procedure, a slower rate of desiccation also maintains viable populations of applied bacteria at fairly reproducible target end-populations. To assess survival in the field, two replicated experiments of 45 melons per pathogen surrogate were spot-inoculated with 100 µl of 8 log CFU/ml *Salmonella typhimurium* (PTVS 337) and *L. innocua* (TVS 451) in two separate 10-cm diameter circles ($A = 19.63\ cm^2$). At 24 hours, 4 days, 7 days and 14 days post-inoculation, 10 melons were removed from the field and the inoculated circles from each melon were removed with a sterile knife, added to 10 ml KPO_4+Tween, and massaged vigorously to remove attached bacteria. Samples were quantified for *Salmonella* and *L. innocua* by surface-plating on CHROM *Salmonella*+rif and CHROM *Listeria*+rif, respectively, following incubation at 37˚C for 24 hours and 48 hours. If samples were not quantifiable (no characteristic colony growth), 10 ml 2X BPW+rif or 2X LEB+rif

were added to the appropriate sample bags with wash buffer and the original rind disc, and incubated at 37˚C for 24 hours and 48 hours, respectively. Aliquots of these enrichment cultures were spot-plated on CHROM *Salmonella*+rif and CHROM *Listeria*+rif. For use in the model wash system, field-inoculated cantaloupe remained attached to the vine in the field for three days prior to harvesting and for immediate use in wash process evaluations, simulating commercial operations.

- *Validation of postharvest mitigation treatments and effects of delays of cooling after sanitizing and temperature fluctuations during postharvest storage on pathogen survival*- Several rounds of studies were implemented throughout the project period to evaluate quality impacts including water loss, softening, mold development, and discoloration at 2.5°C, 7.5°C, and 10°C for storage times up to 28 days. Project staff demonstrated no significant quality reduction under optimal and typical cantaloupe storage and distribution regimes. Project staff determined that some negative impacts at sub-optimal handling conditions were more likely to be experienced by some varieties.
- *Verify, by on-site studies, the efficacy of an evolving commercial process utilizing heat immersion as a rind pasteurization treatment across multiple time-points in each of two seasonal production intervals*- On-site evaluations were conducted at the commercial facility over the two-year project. In the final process design version, project staff were able to substantiate the 2-log reduction of naturally-colonizing Enterobacteriaceae on cantaloupe rind following thermal-shower washing and PAA spray–treatment.

While it is both possible and prudent to continue to refine the design and process control management of the thermal-shower system, practical commercial management and marketing drive frequent change in the operation, which makes conducting this type of research a challenge. Project staff feel a solid foundation for future refinements has been developed and do not plan to continue in the effort directly.

One of the goals of this project was to establish a set of on-going verification parameters for commercial operations. This goal was accomplished by experimentally validating a rapid and non-destructive method for assessing the uniformity of temperature treatment across a high-throughput hot-shower system using digital infrared imaging. This protocol was demonstrated on-site and/or by written communication to both large commercial packers of cantaloupe that were using the thermal pasteurization process. In addition, project staff demonstrated the correlation of significant pathogen reduction in pilot systems with the field-inoculated pathogen surrogates to a 2-log (99%) reduction in total Enterobacteriaceae. An alternative benchmark was shown to be a 2.5-log reduction in native total Coliforms between incoming and post-treatment fruit. This 2-log reduction process control verification standard would be used periodically by these major cantaloupe handlers to demonstrate the system operation within the validated process controls. Both operations report verbally that this is the system they use for microbiological testing of fruit.

Accomplishments that were achieved include the following:

- *Assess the effects of the postharvest heat shock treatments on the quality and shelf life of cantaloupes* – A series of tests with the pilot-heated hydro-shower were conducted to assess the potential for quality impacts, positive or negative, on cantaloupe varieties. High heat, 85–90°C, at short duration was shown to have good efficacy in bacterial reduction but also the likely potential to cause rind injury (discoloration) and accelerated softening and mold development, leading to reduced shelf life at sub-optimal storage temperatures. This injury was variable across varieties and across sequential harvests of a single variety, which was largely due to observed differences in net development and rind thickness. However, the limitation of the commercial systems, due to the capitalization costs of large-scale boiler capacity, restricted the on-site process to contact temperatures of 60–65°C for 30 sec. Across three main cantaloupe varieties being grown by the industry cooperator, there were no observed positive impacts (other than soil removal) or negative impacts on visual quality of storage shelf life over a 14-day period at recommended refrigerated storage temperatures. Abusive temperature storage resulted in accelerated water loss and superficial mold development in some lots of melons tested.

- *Select and preliminarily validate competitive, naturally-occurring rind colonizers capable of growth under refrigerated storage that prevent multiplication of L. monocytogenes on cantaloupe rind during storage* – A collection of the predominate non-pathogenic aerobic heterotrophic bacteria were isolated from the netted rind of cantaloupe following pre-washing and 14 days storage at 2.5°C. The purpose was to determine whether any of these isolates would be viable candidates for a post-pasteurization treatment to competitively exclude growth by *L. monocytogenes* if contamination occurred during handling and packing following the heated hydro-shower. Over 100 isolates were obtained and screened for in vitro antibiosis against the cantaloupe outbreak strains of *L. monocytogenes*. Additional direct competitive tests were carried out with a small group of ten psychrotropic fluorescent pseudomonads shown to grow on cantaloupe rinds and likely to have acceptable probiotic traits. To date, no isolate has been identified as optimal for preventing *Listeria* growth on cantaloupe during refrigerated storage. This work is on-going outside of the project period.
- *To evaluate the potential transfer of low levels of bacterial surrogates from cantaloupe rind surface to edible flesh during fresh-cut operations* – Subsequent to setting this goal, peer-reviewed papers emerged that described the outcome of these objectives sufficiently as to make the effort unnecessary by project staff.
- *Assessment of a revised rind sampling protocol to facilitate comprehensive on-site efficacy evaluations* – Due to several logistic and staffing factors for sample collection and sample processing associated with on-site commercial facilities, three assessments of modified protocols for simplified enumeration of naturally-occurring bacteria on cantaloupe rinds at harvest were conducted. During the project, CPS collected hundreds of whole cantaloupe from incoming, in process at different stages, and final packed fruit, which typically resulted in significant handling issues in the lab but limited variability in bacterial populations. Handling the number of whole melons desired for this project also created significant waste removal costs that became a limiting consideration in 2014. To streamline management of this objective, either two, six, or 12 rind discs (five cm^2) were excised with a sterile metal coring-device from three to five cantaloupes harvested directly from commercial fields on each date corresponding to different California fields, varying seasonal conditions, and crop management practices. Rind discs were placed in buffer solutions and hand-massaged, as described above. Total heterotrophic bacteria were enumerated from these non-inoculated rinds using Plate Count Agar amended with pentachloronitrobenzene and pyruvic acid sodium salt (48 hour incubation at 29°C). Total coliforms were enumerated using CHROMagar ECC amended with pyruvic acid sodium salt (24 hour incubation at 37°C). Enterobacteriaceae were enumerated using Petrifilm Enterobacteriaceae Count Plates (24 hour incubation at 37°C). The degree of variability among an analysis of two, six, or 12 rind discs was sufficiently similar to the bacterial population variability observed during enumeration of whole cantaloupe washes for total heterotrophic bacteria, total Enterobacteriaceae, and total coliforms. Given this outcome, during 2014–2015 project staff elected to use two discs from

replicated cantaloupes for assessing the efficacy of different thermal/antimicrobial wash process treatments at the commercial packing facilities.

Overall, project staff have provided quantitative and qualitative data under laboratory, model system, and commercial system operations which, collectively, highlight key and critical practical elements of thermal wash process design and management for cantaloupe. Laboratory studies conducted early in the project largely confirmed anticipated outcomes for effective surface disinfection of the netted rind using a heated wash process and more substantial inactivation of free-floating bacteria, both naturally-occurring and inoculated, to minimize cross-contamination potential during commercial handling. However, it was also demonstrated that these systems have inherent complexities and the potential for negative quality impacts, if the process controls are not stringent, that present some real challenges under commercial system management. A key consideration determined over the two-year program was the importance of removing suspended solids from the recirculating heated water by filtration to prevent bacterial load accumulation if no effective water chemical sanitizer is used at temperatures less than 80°C due to the practical restrictions on residence time for each cycle. Project staff feel that through working intimately with industry partners to move bench-top studies into commercial reality, the project's stated outcomes have been successfully and substantially achieved, and a template for adoption by other cantaloupe packers in California and beyond has been developed.

A set of operating standards for thermal-wash processes for cantaloupe, and netted melon rind disinfection in general, has been substantiated. Handlers, systems managers, and third-party auditors can use a singular criterion or combined verification criteria of a 2-log to 3-log reduction for total Enterobacteriaceae and total Coliform, respectively, as validated evidence exists for process parameters that are reasonably likely to minimize bacterial pathogen presence on cantaloupe and cross-contamination during the recirculated wash operation. Two major cantaloupe grower-shippers, responsible for a combined volume exceeding 20% of the domestic production, are using this basic system design and control parameters.

Beneficiaries

Growers of cantaloupe and specialty netted melons in California, other domestic shippers, and off-shore suppliers to U.S importers who use a postharvest wash system have or may benefit from the more practical and 'real-world' assessments of the process for partial pasteurization of the netted melon rind surface. By extension, fresh cut processors, foodservice and supermarket retail buyers, and ultimately the consuming public benefit from a better characterized and controlled wash system. As with most of the produce sector in major commodities, fewer than 20 large handlers dominate the market volume, but there are many regional and seasonal suppliers in areas outside California, which have summer rain that require some type of washing system for melon marketability.

In March 2014, the Principal Investigator (PI) presented a detailed technical overview in Atlanta, Georgia, to the Eastern Cantaloupe Grower's Association (approximately 50 attendees). In July 2014, the research findings from this project were presented as one part of a commodity-specific training for the California Department of Public Health Food and Drug Branch jointly with California Food Emergency Response Team (approximately 36 attendees), and broadcast via WEB-EX to the Rapid Response Teams in 18 states.

Final research results were presented by the PI in June at the 2015 CPS Produce Research Symposium in Atlanta, Georgia. Interim results were presented previously via a poster at the CPS Produce Research

Symposium in 2013 in Rochester, New York, and a presentation at the 2014 CPS Produce Research Symposium in Newport Beach, California. Each symposium had approximately 245 attendees. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academics, produce industry representatives, and members of regulatory agencies. The annual symposium provides expert panels to critique the research results after presentation by the researcher, which helps participants evaluate how the results can be used in their respective businesses.

Project results will be disseminated at industry meetings, and streamed through social media sources. Results also will be made available online as follows:

1. Final reports submitted to CPS will be posted on the CPS website: http://www.centerforproducesafety.org/grant_opportunities_awards.php
2. CPS works with the scientists to publish results in scientific journals. Publication dates occur after the project is completed. Abstracts and awards can be found on the CPS website.
3. The Board of Directors and members of the Technical Committee of CPS distribute a series of information briefs throughout the year on the website and through presentations, meetings and webinars. An example of this would be the “2014 CPS Symposium: 10 Lessons Learned” on the CPS website at the following link: http://www.centerforproducesafety.org/amass/documents/document/246/FINAL_2014%20CPS%20Research%20Symposium%20Lessons%20Learned%202%20August%202014_Final.pdf.

The following websites provide additional resources on the final reports and symposium proceedings:

Center for Produce Safety: http://www.centerforproducesafety.org/resources.php
Produce Marketing Association: http://pma.com
Western Growers Association: http://www.wga.com/

It is early in the phase of adoption, as the outcomes are being more widely disseminated, so it is difficult to enumerate the number of direct beneficiaries. The 40 cantaloupe growers and 25 cantaloupe handlers in California are potential beneficiaries. These signatories to the California Cantaloupe Marketing Order potentially benefit in market and consumer confidence by any member shipping cantaloupes under scientifically-supported and validated postharvest handling systems for quality and safety.

Lessons Learned

This was always going to be a complex research project due to the sensitivities inherent in microbial safety concerns for fresh produce, in general, and because the research was conducted on-site and within actual commercial shipping and assessment conditions with retail receivers. Although it was sometimes challenging to obtain the support of some affiliated industry stakeholders, the consistent support of the grower-shipper was exceptional. In an unconventional manner, a key positive outcome was the demonstration that the misinterpreted publicity surrounding the melon hot wash applications to whole melons was dispelled in a timely manner early in the project and hopefully prevented industry members from making costly investments or serious food safety errors.

No unexpected outcomes occurred due to the implementation of this project.

The singular substantial obstacle in the overall outcomes and scope of accomplishment in this project was loss of critical senior and junior technical staff to other employment opportunities throughout the project term.

Replacing trained individuals in this area of research, especially as it involves both intimate interaction with produce industry partners and a significant amount of applied field work, was very difficult and ultimately impossible for the senior personnel. The only solution project staff could implement was the high level of cross-training all technical staff obtained across projects and for more on-site travel and sample collection coverage by the PI and the senior field technical associate. As a result, there was a minor reduction in the execution of sampling frequency with commercial cooperators and locations during the early phases of the project. Much of the model systems' goals were addressed prior to the formal initiation of funding by the senior staff. Therefore, with the departure of some staff, the team lost some of the momentum and continuity in validation studies, but this was compensated for within the overall project.

Additional Information

No publications to peer-reviewed journals were submitted, but several are planned for the near future. The laboratory validation and verification study data from early project outcomes will be combined with the current outcomes in the final process system for future publications. One full draft manuscript from the initial study findings is ready and will be submitted in December 2015. Other manuscript submissions will take place in 2016.

More than 40 presentations specific to or including this research project during its progress have been made at diverse produce industry and food protection forums nationally and internationally. Specific annual updates were made to the California Melon Research Board and at the CPS Produce Research Symposiums in 2013, 2014, and 2105. Presentations of this project in progress were made annually at technical sessions and a cantaloupe food safety symposium at the International Association of Food Protection. Cumulatively, from 2013 to 2015, a conservative estimate would be that 500 attendees were present during these research updates, technical presentations, and symposium talks (outside from the CPS Produce Research Symposium, which has about 245 attendees annually).

USDA Project No.: 67	**Project Title:** Rapid Assessment of Oxidative Stress Induced in Microbes to Evaluate Efficacy of Sanitizers in Wash Water	
Grant Recipient: University of California, Davis Center for Produce Safety (CPS)	**Grant Agreement No.:** SCB12067	**Date Submitted:** December 2015
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** (530) 757-5777	**Email:** bonnie@centerforproducesafety.org

Project Summary

The research was aimed at addressing the need to improve process control of washing and sanitation processes and to provide a platform for rapid evaluation of process efficacy for a large diversity of existing and novel wash water sanitizers. This research project presumes that the activity of various sanitizers is based on inducing oxidative stress in microbes by generating free radicals and oxidizing reactive species. The ability to directly and rapidly correlate the oxidation potential of wash water with oxidative cells within bacteria will provide a critical technology to improve process control and evaluate the efficacy of washing and sanitation procedures.

Washing and sanitation are critical steps in the post-harvest processing of fresh specialty crop produce to reduce food safety risks as well as improve the shelf life. The specialty crop produce industry has a critical need to address these key issues: 1) the influence of organic load on overall efficacy of microbial decay; 2) rapid monitoring of washing and sanitation process efficacy both in terms of quality of wash water and microbial response; and 3) evaluating the efficacy of novel sanitizing agents or combination of existing agents in the processing environment. Thus the research was aimed at developing a novel measurement technique that can rapidly correlate the concentration of sanitizer in wash water with oxidative stress in microbes, for a large diversity of sanitizers. The timeliness of the project is highlighted by the fact that the specialty crop industry has traced some of the recent food safety outbreaks associated with fresh specialty crop produce to less-than-ideal washing and sanitation procedures. In addition, with increasing environmental constraints and the need to conserve water resources, the specialty crop produce industry faces a critical need to optimize the use of water and sanitizers to achieve desired results.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Research activities and accomplishments include the following:

- Developed and validated a novel label-free MR (magnetic resonance) imaging and relaxometry method to rapidly assess the resistance of *E. coli* (non-pathogenic and pathogenic) and *L. monocytogenes* to H_2O_2 (hydrogen peroxide). This resistance (i.e., the ability to degrade H_2O_2) enables the microbes to survive in the presence of hydrogen peroxide–based sanitizers. The MR method measures resistance based on the activity of endogenous enzymes (catalases), and the MR measurements are correlated with a reduction in bacterial culturability. A unique advantage of MR is its ability to measure reactions and interactions in turbid and opaque environments, where sensitivity of optical detection systems is limited.

The results of this task demonstrated the efficacy of the approach to measure the critical concentration of sanitizer required to overcome microbial resistance to the sanitizer.

- Demonstrated application of the MR method to measure oxidative stress induced in microbes in the presence of organic content and turbid samples. In this activity, the goal was to measure the stress response of *E. coli* (nonpathogenic) to H_2O_2 without and with organic load (i.e., in media broth with approximately 15,000 ppm of organic content). The results demonstrated that the MR approach can determine the critical concentration of peroxide-based sanitizers needed in the presence of organic content.

- Developed an optical approach to rapidly assess the oxidative stress induced by NaOCl (bleach) in bacteria in simulated wash water. In this task, an optical spectroscopy method was developed to measure oxidative stress induced in *E. coli* O157:H7 and changes in bacterial physiology (glucose uptake and membrane permeability) upon treatment with NaOCl. This task provided a novel approach to assess the efficacy of chloride-based sanitizers.

- Characterized the role of microbial physiology in influencing the oxidative stress resistance of the microbes. In this activity, both stationary and exponential phase bacteria were evaluated to determine their resistance to the sanitizers. The results of this activity demonstrated that stationary phase microbes have significantly higher resistance to sanitizers as compared to exponential phase microbes.

- Compared the oxidative stress induced damage in microbes with membrane damage, uptake of glucose, and reduction in culturability. The results of this task demonstrated that the oxidative damage induced by peroxide-based and chloride-based sanitizers is significantly different.

The project was focused on sanitation in a fresh specialty crop produce environment, in which organic content is a significant and unique challenge. The microorganisms selected for the study are known to be of significant concern in the fresh specialty crop produce industry. This project only benefited specialty crops.

The project was developed in partnership with researchers at University of California, Davis who provided guidance in design and analysis of microbial evaluation, and expertise with the development of the MR approach as well as access to lab facilities and an experienced research group to support this research. Another project partner, based at Drexel University, provided research expertise in selection and validation of optical probes for measuring the oxidative stress resistance of microbes. This contribution facilitated the measurements of oxidative stress response of bacteria to both peroxide- and chloride-based sanitizers.

Goals and Outcomes Achieved

The completed activities include:

- Development of novel approaches (both optical and MR) to measure oxidative stress resistance of microbes to sanitizers.

- Characterization of the differences in oxidative stress response of pathogens and non-pathogenic microbes to sanitizers, and correlation of oxidative stress resistance measurements with reduction in microbial load.

- Evaluation of the influence of organic content on the efficacy of sanitizers.

The outcome measures were both short and long term. In the short term this research project has demonstrated good correlation between oxidative stress induced by the sanitizers and reduction in microbial load, and also has provided an approach to measure oxidative stress in microbes using portable or bench scale systems. In the long term this research will require translation of these research findings and developments to fresh specialty crop produce washing and sanitation operations. Collaboration with industry partners will enable the translation of these results.

All three goals outlined in the project proposal were met. An MR approach was developed to measure oxidative stress resistance of microbes to sanitizers. Signal intensity in MR imaging is a function of several factors including proton density and spin-lattice relaxation time (T_1). In this MR approach, the changes in contrast properties were induced by a reduction in T_1. (The T_1 relaxation time describes the energy exchange between nuclear spins and their surrounding environment [lattice].) These changes were attributed to generation of paramagnetic species, such oxygen, upon interaction of the intracellular enzymes (catalases) in the microbes with H_2O_2. Oxygen is a well-known paramagnetic contrast agent that can reduce the T_1 relaxation. Biochemical interactions of H_2O_2 with intracellular catalases are known to generate oxygen. This approach was successfully tested for peroxide-based sanitizers by correlating the changes in MR signal intensity with reductions in bacterial culturability.

Due to a lack of specific MR changes induced by chloride-based sanitizers, an optical approach was developed to measure oxidative stress. Using optical spectroscopy methods, radical sensitive fluorescence tracers were evaluated for measuring the oxidative stress induced in *E. coli* O157:H7 upon treatment with NaOCl, and measuring changes in bacterial physiology (glucose uptake and membrane permeability) induced by sanitizers; these changes were then compared with the reduction in bacterial culturability.

Using both optical and MR approaches, the oxidative stress resistance of microbes was characterized and compared with reduction in microbial count. The influence of organic content on the efficacy of sanitizers also was characterized by measuring changes in bacterial culturability. In addition, the influence of the physiological state of microbes in their resistance to sanitizers was studied. The results demonstrated that stationary phase microbes are more resistant to sanitizers than are exponential phase microbes. This enhanced resistance was predicted by the MR and optical measurements.

The baseline data in this project demonstrate that rapid assessment of the oxidative stress response or response of microbial physiology to sanitizers can predict efficacy of the sanitizer. To translate this finding to industrial application, further research and translational activities are needed. These activities need to be planned in co-operation with industry collaborators.

Major successful outcomes are as follows:

- MR methods can predict the oxidative stress resistance of microbes to hydrogen peroxide. This finding implies that this approach has significant potential to measure efficacy of peroxide-based sanitizers.

- The results demonstrated good correlation between oxidative stress resistance based on MR measurements and the reduction in microbial load. From MR measurements, one can predict the critical concentration of sanitizer required to induce greater than 2 log reductions in microbial load.

- The results also demonstrated no significant differences in microbial resistance of pathogenic and non-pathogenic bacteria but significant differences in microbial resistance between stationary and exponential phase microbes.

- An optical approach based on the uptake of glucose was effective in predicting the critical concentration of NaOCl above which significant reductions (greater than 2 log) in microbial load can be achieved.

- Chlorine-based sanitizers induced significant damage to cell membranes whereas no significant membrane damage was detected using hydrogen peroxide.

Beneficiaries

The results of this project benefit the fresh specialty crop produce industry engaged in packaging and minimal processing of leafy greens, including lettuce, spinach, cilantro, and parsley, and other specialty crops such as tomato. Development of a direct measurement approach for rapid assessment of the influence of sanitizers on microbes and prediction of the reduction in microbial count could complement the current methods of controlling sanitizer concentration. In addition, the project results based on the strains evaluated in this study indicate that non-pathogenic and pathogenic *E. coli* have a similar response to sanitizers. This finding can help industry select non-pathogenic surrogates to evaluate the efficacy of sanitizers.

This project benefits the entire fresh specialty crop produce washing and packaging industry in the state of California and the country. According to the most recent (2012) Census of Agriculture, there are 42,729 farms of specialty crop growers in the state of California, which represents $23.9 billion in sales (http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Rankings_of_Market_Value/California/index.asp).

The University of California, Davis, researcher leading the project presented final research results in June at the 2015 Center for Produce Safety (CPS) Produce Research Symposium in Atlanta, Georgia. Interim results were presented at the 2014 CPS Produce Research Symposium in Newport Beach, California. Each symposium had approximately 245 attendees. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academics, specialty crop produce industry representatives, and members of regulatory agencies. The annual symposium provides expert panels to critique the research results after presentation by the researcher, which helps participants evaluate how the results can be used in their respective businesses.

Project results will be disseminated at industry meetings, and streamed through social media sources. Results also will be made available online as follows:

- Final reports submitted to CPS are posted on the CPS website: http://www.centerforproducesafety.org/grant_opportunities_awards.php

- CPS works with the scientists to publish results in scientific journals. Publication dates occur after the project is completed. Abstracts and awards can be found on the CPS website.

- The Board of Directors and members of the Technical Committee of CPS distribute a series of information briefs throughout the year on the website and through presentations, meetings and webinars. An example of this would be the "2014 CPS Symposium: 10 Lessons Learned" on the CPS website at the following link: http://www.centerforproducesafety.org/amass/documents/document/246/FINAL_2014%20CPS%20Research%20Symposium%20Lessons%20Learned%202%20August%202014_Final.pdf.

The following websites provide additional resources on the final reports and symposium proceedings:
Center for Produce Safety: http://www.centerforproducesafety.org/resources.php
Produce Marketing Association: http://pma.com
Western Growers Association: http://www.wga.com/

Lessons Learned

The project demonstrated that rapid assessment of oxidative stress response or response of microbial physiology to sanitizers can predict efficacy of the sanitizer. The results also indicate that stationary phase microbes are more resistant to oxidative stress induced by sanitizers as compared to exponential phase microbes. Throughout the project, collaboration between engineers, a chemist, and a microbiologist enabled development of a novel approach to measure the response of microbes to sanitizers. The positive experience from this collaborative project is evidence that more interdisciplinary research needs to be encouraged to address the challenges of food safety.

The microbial physiology of a strain was found to be a more dominant factor in influencing the resistance to sanitizers as compared to the differences in pathogenic and non-pathogenic strains. Further studies are required to validate these findings using a large diversity of strains and conditions.

Additional Information

Two presentations and one peer-reviewed publication (Attachment 1) have resulted from this project to date:
P. Le, L. Zhang, V. Lim, M.J. McCarthy, N. Nitin, A novel approach for measuring resistance of *Escherichia coli* and *Listeria monocytogenes* to hydrogen peroxide using label-free magnetic resonance imaging and relaxometry. *Food Control*, 50, 560–567, 2015.
P. Le and N. Nitin, Fluorescence spectroscopy approach for rapid assessment of antimicrobial efficacy of wash water for post-harvest processing of fresh produce, Presented at IFT Annual Meeting, New Orleans, LA, 2014.
P. Le and N. Nitin, Measuring oxidative stress response of microbes using magnetic resonance (MRI) and spectroscopy (NMR), Presented at IFT Annual Meeting, Chicago, IL, 2013.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

<table>
<tr><td>USDA Project No.:
68</td><td colspan="2">Project Title:
Reducing the risk for transfer of zoonotic foodborne pathogens from domestic and wild animals to vegetable crops in the Southwest desert</td></tr>
<tr><td>Grant Recipient:
University of California, Davis
Center for Produce Safety</td><td>Grant Agreement No.:
SCB12068</td><td>Date Submitted:
December 2015</td></tr>
<tr><td>Recipient Contact:
Bonnie Fernandez-Fenaroli</td><td>Telephone:
530-757-5777</td><td>Email:
bonnie@centerforproducesafety.org</td></tr>
</table>

Project Summary

In May 2010, an outbreak of *Escherichia coli* O145 infections was linked to romaine lettuce grown in the desert southwest. This was the first known leafy green-related Shiga toxin-producing *Escherichia coli* (STEC) outbreak traced to the region. Based on initial investigations by the Center for Disease Control and the Food and Drug Administration (FDA) following the outbreak, pre-harvest contamination was suspected, although no laboratory confirmed source was determined.

According to reports from regional growers, wildlife intrusions into produce fields are common in the area. Frequent animal—most notably from dogs, javelina, and deer—sightings and signs (tracks, scat) in fields may be associated with damage and subsequent destruction of crops with economic losses. The food safety risk from these intrusions by wildlife is unclear, as limited information exists in the literature on the prevalence of foodborne pathogen infections among wildlife in the southwestern desert growing region. A recently published Center for Produce Safety (CPS) Rapid Response study of domestic dogs and coyotes in the region which was conducted during the 2010-2011 growing season found an STEC prevalence of 0% but *Salmonella* prevalences of 9.2 and 32.0% in dogs and coyotes, respectively. Wild bird and rodent intrusions into produce fields in the region are also of concern. An important migration and wintering stop for waterfowl lies approximately 25 miles northeast of Yuma, and the nearby Colorado River provides habitat to attract many bird species. The potential exists for birds to act as reservoirs of pathogenic bacteria or serve as vectors of produce contamination from nearby concentrated animal feeding operations (CAFOs), several of which are located in Yuma or surrounding counties.

Applied research was conducted over two years to determine if local livestock, terrestrial and avian wildlife populations in the desert southwest are reservoirs of STEC and *Salmonella*. Regional knowledge gaps in produce food safety in an under-studied, but economically important, leafy green production area of the desert southwest were addressed. The study was timely given the need to better understand animal hazards and best practices that can be incorporated into the leafy green marketing agreements in Arizona and California. The study is also timely given the proposed FDA produce safety rule. The results from this study provide baseline data and information on risk factors that may impact the development of science-based best food safety practices in order to eliminate or minimize the risk of microbial contamination of fresh produce, while maintaining environmental stewardship.

During the 2010-2011 growing season in the Southwest desert, the first phase of this study was conducted by examining local canid (dog, coyote) reservoirs in collaboration with leafy greens industry partners (CPS Rapid Response Project). The present project represents Phase 2 of this work and examines the potential role of domestic cattle-wildlife interactions in the dissemination of foodborne pathogens and aims to develop co-management strategies for risk reduction.

This project does not build upon a previous Specialty Crop Block Grant Program funded project.

Project Approach

A two-year study was conducted to evaluate if local livestock, terrestrial and avian wildlife populations in the desert southwest are reservoirs of *Salmonella enterica* and STEC, and to determine movement patterns of wildlife between CAFOs and produce fields. Fecal samples from cattle, wild birds and rodents were collected at least once each season during 58 sampling events that took place from March 2013 through November 2014 in southern Arizona and California. Wild birds were fitted with radio-transmitters and rodents with ear tags to determine movement patterns. Fecal and colon samples were collected from feral swine taken by USDA Wildlife Services in Arizona and New Mexico. Pathogens were isolated by pre-enrichment followed by immunomagnetic separation (STECs), selective plating, and PCR confirmation. A total of 750 cattle and 1,225 wildlife samples were analyzed. *Salmonella* was cultured from 6 wild bird species (brown-headed cowbird, common raven, great-tailed grackle, red-winged blackbird, white-crowned sparrow); 3 species were positive for non-O157 STEC (brown-headed cowbird, red-winged blackbird, white-crowned sparrow). *Salmonella* was cultured from 6 wild rodent species (Botta's pocket gopher, cactus mouse, desert pocket mouse, Merriam's kangaroo rat, round-tailed ground squirrel, western white-throated woodrat; one desert pocket mouse was positive for non-O157 STEC. No STEC O157 was isolated from wild birds, rodents, or rabbits. *Salmonella*, non-O157 STEC and STEC O157 were detected in cattle and feral swine samples. Cattle showed a significant peak in the prevalence of *Salmonella* and STEC during fall compared with spring and summer ($p = 0.019$). Rodents and birds trapped at CAFOs did not show a significant seasonal difference in pathogen prevalence, but movement data indicated that birds traveled regularly between the CAFO and produce fields in southern Arizona. The majority of non-O157 STEC isolates did not encode all of the virulence markers associated with human infections, and did not belong to the "top 6" clinically serotypes. It was concluded that growers should continue efforts to deter large flocks of nuisance birds from defecating in produce fields, and may need to increase the buffer zone distance from a leafy green field to a CAFO beyond 400 feet if environmental assessments indicate a significant risk of bird activity in the field. The results from this study provide baseline data and information on risk factors that may impact the development of science-based best food safety practices in order to eliminate or minimize the risk of microbial contamination of fresh produce, while maintaining environmental stewardship.

The CPS believes this is the first study of STEC prevalence and seasonality on CAFOs in the southwestern desert. These findings may benefit livestock producers. Because testing cattle samples was part of the study design (objectives 1 and 2), all funds were used solely to enhance the competitiveness of specialty crops. CPS staff is in constant communication with both the California industry and the scientists working on this project to ensure only specialty crops benefited from this project.

Project partners include the Arizona Game and Fish Department which provided equipment and facilities. The researcher who initiated the project in early 2013 left UC Davis shortly thereafter. A skilled postdoctoral scholar was hired who led the field team collecting samples and data, coordinated with the laboratory, maintained a large confidential database, conducted data analysis, and gave presentations to stakeholders. The industry collaborator devoted time to identify collaborating industry partners, facilitate sample collection, and assist with communication of findings to stakeholders in the desert production region.

Goals and Outcomes Achieved

All three project objectives were achieved.

1) To determine if domestic animals and terrestrial and avian wildlife species in the desert southwest produce production region are reservoirs of Shiga toxin-producing *E. coli* (STEC) or *Salmonella*.
2) To determine the extent to which wildlife and cattle share genetically related strains of STEC and *Salmonella*, and measure the movement of strains from livestock operations to produce fields by wildlife populations.
3) Extend knowledge of preventing produce contamination by domestic animals and terrestrial and avian wildlife populations to the produce and livestock communities.

The long-term goals of the project are specifically related to Objective 3, which is to extend knowledge to the produce and livestock communities to prevent produce contamination by domestic animals and terrestrial and avian wildlife populations. Numerous presentations to stakeholders have been provided at scientific conferences and local industry workshops and meetings regarding the prevalence of pathogens and the likelihood of the transfer of pathogens between CAFOs and produce fields by wildlife. Work continues with the community on developing protocols to prevent birds from potentially contaminating produce fields while in flight.

Objective 1 Results:
Cattle, wild bird, and wild rodent/rabbit fecal samples were collected during 58 sampling events that took place from March 2013 through November 2014. Sampling efforts were primarily focused on two produce farms and two CAFOs where staff had the most trap success early in the project, and where the locations were most suited to addressing the objectives. During each trapping event, staff set up as many as 6 mist nets and 2 ground traps for birds, 6 Tomahawk traps for rabbits, and 100 Sherman traps for rodents.

Trap success varied by location and bird versus rodent. Specifically, overall trap success for rodents was 33% with a 15% rate at CAFOs compared with 39% and 37% along roads and natural habitat adjacent to produce fields. In contrast, few birds were trapped in mist nets at the produce fields (<1 per net) compared with natural habitat adjacent to the produce field (4 per net) and on the CAFO (3 per net).

A total of 750 cattle and 1,225 wildlife samples were collected during the study period, including 775 wild rodents, 383 wild birds, 1 wild rabbit, and 53 feral swine (Table 1). Diversity was highest among wild birds with 24 different species (Table 2) identified compared with 14 wild rodent species (Table 3). *Salmonella* was cultured from 6 wild bird species (brown-headed cowbird, common raven, great-tailed grackle, red-winged blackbird, white-crowned sparrow); 3 species were positive also positive for non-O157 STEC (brown-headed cowbird, red-winged blackbird, white-crowned sparrow). *Salmonella* was cultured from 6 wild rodent species (Botta's pocket gopher, cactus mouse, desert pocket mouse, Merriam's kangaroo rat, round-tailed ground squirrel, western white-throated woodrat; one desert pocket mouse was also positive for non-O157 STEC (Table 3). No STEC O157 was isolated from wild birds, rodents, or rabbits.

The overall prevalences for CAFO cattle samples were 6.9% *Salmonella*, 38.4% non-O157, and 17.3% STEC O157 (Table 1). Feral swine samples were also positive for *Salmonella* (6.9%), non-O157 STEC (7.5%) and STEC O157 (1.9%). Javelina prevalences were 15.4% for *Salmonella*, 7.7% for non-O157 STEC, and 0% STEC O157. Seasonal trends were observed with wild birds showing peak pathogen prevalence of *Salmonella* and non-O157 STEC in spring when they are most active, while rodents and cattle show a peak in *Salmonella* fecal shedding in the fall when cattle also show a peak in non-O157 STEC (Table 4; Figures 1-3). Cattle show a significant peak in the prevalence of *Salmonella*, *E. coli* O157 and non-O157 STEC during fall compared with spring and summer ($p = 0.019$). Rodents and birds trapped at the CAFO do not show a significant seasonal difference in pathogen prevalence, but movement data do indicate that birds traveled regularly between the CAFO and produce fields as discussed below.

Objective 2 Results:
A total of 27 of the ear tagged rodents were captured either once or twice again on future dates after their initial capture. None of the rodents were trapped in any locations away from their initial point of capture. In fact, some rodents were recaptured in the same or close to the same traps in the same order that they were trapped on their first trap date.

A total of 103 birds captured on the Arizona CAFO were fitted with radio-transmitters to track their movement patterns. The majority of these birds were red-winged blackbirds, *Agelaius phoeniceus* (n=66). Table 5 shows the number of each bird species fitted with a radio-transmitter during each season. As shown in Figure 5, preliminary analysis of bird movement from the CAFO demonstrates that birds frequently travel between the CAFO and beyond the 400 feet buffer zone, the minimum area away from livestock per current Arizona and California Leafy Green Marketing Agreement (LGMA) food safety guidelines.

Virulence profiling:
Serogrouping of 305 STEC isolates revealed 30 O-antigen types (Table 6). The majority of cattle (117/130) and feral swine (1/1) STEC O157 were serotype *E. coli* O157:H7 and encoded *stx1* and/or *stx2*, *eae*, and *hly* genes. Among the non-O157 STEC isolates, almost 50% belonged to 6 serogroups (O136, O157, O171, O109, O2, and O160) and did not encode the *eaeA* gene. Of note, only 14 (~5%) non-O157 STEC isolates (O103, O145, O26, O45) belonged to the "top 6" clinically relevant serogroups. Approximately 50% of a subset of isolates (n = 36) analyzed with Roka classified these as STEC based on more stringent criteria. One strain (feral pig) was found to carry a putative virulence gene (*saaD*). Additional molecular studies to source track isolates from wildlife and cattle samples are underway. Pulsed-field gel electrophoresis will be used to compare selected isolates from cattle and wildlife at different distances from point of collection.

Objective 3 Outreach Results:
The team conducted 10 oral presentations and showed three posters at scientific conferences and stakeholder workshops, including two posters that were submitted for approval to the International Association for Food Protection for their upcoming annual meeting. The conferences where presentations were made by the project's co-authors include the 26th Vertebrate Pest Conference, the Governor's Conference/STEC Coordinated Agricultural Project Annual Meeting, the Center for Produce Safety Research Symposium, the American Veterinary Medical Association, the Wildlife Disease Association Annual Conference, the Yuma Safe Produce Council Pre-Season Meeting, The University of Arizona Yuma Agricultural Center Pre-Season Vegetable Workshop, the University of Arizona Soil, Water, and Environmental Science Department

Colloquium, the University of Arizona Food Safety Consortium Annual Meeting, and the Pesticide Applicators Professional Association Continuing Education Workshop.

Major successful outcomes:
There were a number of major successful outcomes from this project. Not only was a successful working relationship established with two CAFOs, but staff also gained the trust and confidence of 2 major growers in the southwest desert who allowed research to be conducted in 8 of their produce fields. As a result of wild animal trapping for this project, staff were able to share with the growers which species of rodents and birds were most common in the areas surrounding their fields. This allowed them to develop a more targeted approach to wildlife control.

Specifically, staff successfully trapped wild rodents and birds to collect fecal samples directly from these animals, and was able to obtain fresh cattle fecal samples from two participating CAFOs in southern California and southern Arizona. Staff were able to collect samples often enough and in great enough quantity to allow for seasonal comparisons of prevalence and future modeling of risk factors. Additionally, the availability of expertise from Arizona Game and Fish Department biologists allowed staff to apply wildlife capture-recapture and radio-telemetry techniques to a produce food safety project. Wild rodents were fitted with ear tags and wild birds with radio-transmitters that were secured to their bodies with backpacks. Four receivers and six antennae were set up in a total of four field locations, along with solar panels to ensure constant functioning. The team maximized use of the funds and demonstrated the value of a multi-disciplinary team in addressing co-management of agriculture production systems within a desert environment.

This research also builds on findings from a previous CPS Rapid Response project and fostered continued close collaborations with the leafy greens industry in Yuma, Arizona, and southern California. Expertise from the UC Desert Research and Extension Center (DREC) in southern California and the University of Arizona Yuma Agricultural Center was utilized, thereby strengthening relationships with cooperative extension in both states. Through these relationships, the team gained the trust and cooperation of growers and CAFO managers who helped in accessing field sites and establishing receiver locations. The knowledge gained from the study was shared with stakeholders in multiple venues, who are the main beneficiaries of this project.

The project PI presented final research results in June at the 2015 CPS Produce Research Symposium in Atlanta, GA. Interim results were presented previously at the 2014 CPS Produce Research Symposium in Newport Beach, CA. Both symposia had approximately 245 attendees. The participants included California regional and national growers/shippers, retail and food service buyers, scientists, academics, produce industry representatives, and members of regulatory agencies. The annual symposium provides expert panels to critique the research results after presentation by the researcher, which helps participants evaluate how the results can be used in their respective businesses.

Project results will be disseminated at industry meetings, and streamed through social media sources. Results also will be made available online as follows:

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The following websites provide additional resources on the final reports and symposium proceedings:
Center for Produce Safety: http://www.centerforproducesafety.org/resources.php
Produce Marketing Association: http://pma.com
Western Growers Association: http://www.wga.com/

Beneficiaries

Beneficiaries include the leafy green and other produce industry growers, handlers, shippers and related industries concerned with potential risks from domestic and wild animal reservoirs of zoonotic enteric pathogens that could contaminate fresh produce.

According to the most recent (2012) Census of Agriculture there are 42,729 farms of produce crop growers representing $23.9 billion in sales in the state of California http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Rankings_of_Market_Value/California/index.asp.

Lessons Learned

Seven key findings from the project include:

1. Desert fauna including wild rodents, birds, and javalina may serve as reservoirs of *Salmonella* and non-O157 STEC, but they do not appear to be significant sources of *E. coli* O157, even when in close proximity to high density cattle operations with documented fecal shedding of *E. coli* O157:H7. As shown previously, cattle and feral swine fecal material is much more likely to contain *E. coli* O157:H7 compared with small mammals and avian species. However, due to the heat, feral swine are not found in the southern-most leafy green production areas of Arizona and California.
2. Wild rodent home ranges are small enough that these animals are often captured in the same location on multiple dates. It is unlikely that rodents travel from CAFOs to produce fields if the distance between the two is further than a 0.5 hectare area or if there are substantial barriers between the two, such as a canal or major roadway. Therefore, it is highly unlikely that wild rodents transmit pathogens directly from CAFOs to produce fields.
3. Rodent density was relatively low at the CAFOs, but high (>30% trap success) along leafy green field edges and adjacent habitat; additional studies should evaluate if the buffer (typically dirt roads between fields) between rodent habitat and produce is sufficient to minimize intrusions into fields.
4. Birds travelled regularly between CAFOs and distant sites, sometimes on a daily basis, and their flight paths sometimes take them directly over produce fields. Since birds do show seasonal variation in their

prevalence levels of *Salmonella* and non-O157 STEC, growers are advised to deter birds from their fields during the growing and harvesting season.

5. Bird density and diversity was highest at the CAFO and in natural habitat adjacent to produce fields. During the study, birds were rarely captured within fields suggesting that they spent most of their time between CAFOs and roosting areas. Future studies should focus on the specific attractants that cause birds to enter produce fields (e.g., irrigation, harvest, etc.) and target bird control resources to these higher risk activities.
6. If leafy green fields are near CAFOs and experience significant bird intrusions (especially large groups of brown-headed cowbirds, ravens, grackles, blackbirds, and sparrows), the minimum 400 foot buffer zone between the field and the perimeter of a CAFO, recommended as an LGMA food safety practice, may need to be increased.
7. The majority of STEC isolates obtained in this study were not among the "top 6" non-O157 serogroups (O26, O111, O103, O121, O45 and O145) and did not encode genes for intimin and other virulence markers typically associated with human infections. Rapid discrimination of clinical relevance would improve risk management decisions and, potentially, avoid unnecessary destruction of crops.

An unexpected outcome that occurred was that the Postdoctoral Researcher hired to implement the fieldwork portion of the project was ultimately hired as an Extension Specialist in Yuma, where the project took place, and is now the person responsible for working with the local agricultural community in developing and implementing strategies to prevent animal intrusion and ultimately to improve pre-harvest food safety.

Fieldwork is always challenging, especially when using new equipment or techniques. One of the challenges was figuring out how to put a backpack on a bird quickly, efficiently, and with the least amount of stress to the animals and researchers. It would have been beneficial to practice backpack fittings on live birds prior to actually doing it in the field. It also would have been useful to be able to practice using the equipment, like receivers, antennae, and solar panels in advance, but there were delays in the shipment of this equipment so staff needed to deploy them when they arrived. As a result, staff did a lot of troubleshooting in the field, but the company that supplied much of the technology (Lotek) was very helpful with phone support. Staff also learned how to set up a solar panel with a battery to power nearly any stationary item in the field, which will be useful in future desert-based field projects. Staff also have an abundance of experience and have already been called upon to share with other researchers who are interested in using the same equipment. CPS is developing new collaborations and connections as a result. One animal that eluded staff during the entire field season was rabbits. Staff regularly set and baited six rabbit traps, but never caught one until the last day of trapping when a juvenile rabbit was caught in a Sherman trap. There were two complications with the laboratory work. First, the cost of *Salmonella* serotyping doubled so staff decided to focus on STEC serotyping instead and use pulsed-field gel electrophoresis (PFGE) to subtype *Salmonella* strains; however, due to delays in training new staff to conduct PFGE analysis, and delays due to a major piece of equipment needing repair, *Salmonella* strain characterization is not included in this report.

Additional Information

See below for Publications and Presentations; see attachment for Tables and Figures.

Publications and Presentations:

Date	Title	Organization/ Conference	Location	Presenter
5 Mar 2014	Zoonotic enteric pathogens of wild boar, feral swine, and javelina (Order: *Artiodactyla*)	26th Vertebrate Pest Conference	Waikoloa, HI	Michele Jay-Russell
5 Mar 2014	Poster: An approach to examining the wildlife and livestock interface with leafy green produce in the southwest desert	26th Vertebrate Pest Conference	Waikoloa, HI	Paula Kahn-Rivadeneira
29 May 2014	The role of wildlife in the dissemination of E. coli O157:H7 and other STECs to fresh produce	Governor's Conference/STEC Coordinated Agricultural Project (CAP) Annual Meeting	Lincoln, NE	Michele Jay-Russell
25 June 2014	Reducing the risk for transfer of zoonotic foodborne pathogens from domestic and wild animal to vegetable crops in the southwest desert	Center for Produce Safety Research Sympsium	Newport Beach, CA	Michele Jay-Russell
27 July 2014	The wildlife-livestock interface in produce food safety	American Veterinary Medical Association Annual Convention (Featured Speaker)	Denver, CO	Michele Jay-Russell
31 July 2014	The role of wildlife in the transfer of enteric zoonotic pathogens from livestock to leafy green produce fields in the desert southwest	Wildlife Disease Association Annual Conference	Albuquerque, NM	Paula Kahn-Rivadeneira
21 Aug 2014	Working together to address animal intrusions and improve food safety in the Yuma Valley and beyond	Yuma Safe Produce Council Pre-Season Meeting	Yuma, AZ	Paula Kahn-Rivadeneira
4 Sep 2014	Reducing the risk for transfer of foodborne pathogens from animals to vegetable crops in the desert southwest	University of Arizona, Yuma Agricultural Center, Pre-Season Vegetable Workshop	Yuma, AZ	Paula Kahn-Rivadeneira

15 Sep 2014	Birds, rodents, cattle, and salad, Oh My! Zoonotic pathogen risks associated with the livestock:wildlife interface near leafy green produce fields in the desert southwest	University of Arizona Soil, Water, and Environmental Science Department Colloquium	Tucson, AZ	Paula Kahn-Rivadeneira
10 Oct 2014	Evaluating pathogen transfer between livestock and wildlife, and the resulting risk to leafy green produce in the southwest desert	University of Arizona Food Safety Consortium Annual Meeting	Tucson, AZ	Paula Kahn-Rivadeneira
9 Dec 2014	Species diversity of wild rodents and birds in and around leafy green produce fields - Which critters pose the most risk?	Pesticide Applicators Professional Association Continuing Education Meeting	Indio, CA	Paula Kahn-Rivadeneira
31 July – 3 Aug 2015	Poster: Spatial and temporal factors affecting prevalence of *Salmonella* and STEC in wild birds and rodents in proximity to CAFOs and vegetable fields in the Southwest desert	International Association for Food Protection Annual Meeting (submitted)	Portland, OR	Paula Kahn-Rivadeneira
31 July – 3 Aug 2015	Poster: Diversity of O-serotypes and virulence markers of STEC isolates from feedlot cattle and wildlife in the desert southwest	International Association for Food Protection Annual Meeting (submitted)	Portland, OR	Peiman Aminabadi

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

SPECIALTY CROP BLOCK GRANT PROGRAM

FINAL PERFORMANCE REPORT

USDA Project No.: 69	**Project Title:** Improved diagnostics and quantification assays for *Verticillium* species important to California agriculture	
Grant Recipient: United States Department of Agriculture, Agricultural Research Service (USDA-ARS)	**Grant Agreement No.:** SCB12069	**Date Submitted:** December 2015
Recipient Contact: Frank Martin	**Telephone:** (831) 755-2873	**Email:** frank.martin@ars.usda.gov

Project Summary

Members of the fungal genus *Verticillium* (*V.*) can be particularly devastating for California specialty crop growers due to the broad host range and ability to survive in the soil for long periods of time. A search of the fungal-host database generated a list of 2,290 entries for the genus, many of these representing specialty crops in California (lettuce, strawberry, spinach, cauliflower, potato, tomato, grape, artichoke, many ornamentals, etc). Current techniques for quantifying inoculum in the soil are not optimal for a variety of reasons; including the length of time it takes to get results and the inability to differentiate some species on the soil dilution plates. For these species, this makes it impossible for growers to get an accurate assessment of potential disease problems in the fields. Species identification is further complicated by the fact that there are species that can be differentiated only by molecular methods (even when they are cultured morphology will not differentiate). The availability of a rapid and accurate molecular technique would improve the ability of growers to evaluate the risk of planting susceptible crops early in the decision making process (pre-plant soil fumigation is the primary means for disease management). To address this need for *V. dahliae*, project staff developed an accurate (down to 1-2 propagules/g soil) and rapid molecular soil quantification assay and validated with field soil samples in the Project Investigator (PI)'s lab. Markers were also developed for detection of several other *V.* species, but data is needed to design and test markers for the remaining described species.

V. species are capable of causing disease on a broad range of California specialty crops, and, due to their ability to survive in the soil for long periods of time and the lethal nature of the diseases they cause, are responsible for significant losses in production. Without a means for rapidly and accurately determining if the pathogens are present and in high enough numbers to cause disease, growers are not able to make informed management decisions on crop selection or on pre-plant soil treatment to reduce the impact of the pathogens. Currently available techniques are not capable of addressing this need so the successful completion of this project will provide useful technology for the specialty crop industry.

This project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

The following activities were completed throughout the grant period:

- Establish culture collection - cultures have been purchased and collected from various international collaborators from Canada and overseas. The collection of *V.* species in the collaborator's laboratory include 210 isolates representing all the 10 species known and many isolates that represent the diversity of species in the state. Cultures used in the recent evaluation of the genus by Inderbitzin et al. (2011) were included in this collection as well.

- Sequence loci used for developing species specific markers - The locus used as the target for designing TaqMan probes has been sequenced from 155 cultures representing 10 different *V.* spp.
- Evaluate sequence alignments for marker design – evaluation was completed.
- Design species specific TaqMan probes, optimize amplification conditions and evaluate specificity - Design and validation of genus specific amplification and species-specific detection TaqMan probes for each of the ten recognized *V.* species was completed (*V. albo-atrum, V. alfalfae, V. dahliae, V. isaacii, V. klebahnii, V. longisporum, V. nonalfalfae, V. nubilum, V. tricorpus,* and *V. zaregamsianum*).
- Confirm specificity of the different species-specific TaqMan probes in California - multiple DNAs from all 10 species represented in the culture collection were sent to California and tested to ensure specificity for the genus specific primers and each species specific probe. To determine if background detection of other soil fungi could occur, the markers were also tested with a range of related and common soil fungi. While the amplification protocol was the same as developed in Canada, different types of equipment were used to run the assay and since the same results were obtained, it should be possible to easily transfer the technology to other labs.
- Compare soil counts with real time polymerase chain reaction (PCR) results to determine relationship between the two - There were 8 soils each from California and Canada with a variety of different *V.* species (spp.) that were evaluated for establishing the relationship between plate counts and results of the TaqMan assay (DNA from colonies on the plates was extracted and species identification confirmed by molecular methods to ensure accuracy). Additional soils are currently under evaluation to confirm this relationship and current results indicate these markers will be useful for quantification of soil populations for the genus.
- Genomic sequencing of *V.* species and assembly of mitochondrial genomes - genomic sequencing completed and the mitochondrial genomes were assembled for all 10 species.
- Design species specific diagnostic markers from mitochondrial sequences and validate - potential markers were designed and sequencing of target loci in additional isolates is in progress to confirm the level of sequence conservation.
- Evaluate the ability of using the *V.* genus specific primers to amplify the target region from DNA extracted from soil to assess *V.* species communities - the primers for the genus specific amplicon were able to amplify the appropriate template from DNA extracted from soil samples, confirming this marker could be used for in metagenomic studies for evaluating species communities.
- Evaluate the isothermal diagnostic technique recombinant polymerase amplification for utility in detecting *V.* spp. - The technology for the RPA assays were sent to the project collaborator, but unfortunately there was a quality control problem with the lot number of the kit that project staff are working with the company to resolve (there was a significant loss of sensitivity when tested with the project staff's other RPA assays).

Completed research that came as a result of the above project activities:

- Improved techniques for extraction of DNA from soil - one of the limiting factors for accurate quantification of organisms in the soil is the ability to get clean DNA that does not contain contaminants that inhibit amplification, which reduces the sensitivity and accuracy of the technique. The technique that was previously used to extract DNA was improved, thereby improving the reliability of the results obtained.
- Internal control - in order to get accurate results it is important to know how clean the soil DNA is (does not have inhibitors that reduce template amplification). One way of testing for this is to add a

unique piece of DNA not found in nature and evaluate how well it is amplified when it is added to the extracted soil DNA compared to when amplified without the soil DNA. The internal control from project staff's prior work was modified to work with this new assay system.

- Assay validated on a range of real time PCR thermal cyclers - To determine if problems would be encountered when labs with different types of equipment tried to run the assay, the Canada and California labs tested a total of three different brands of equipment and found all to work equally well. This demonstrates the stability of the marker system design for working in different labs that may have different types of equipment.
- Confirmed specificity and utility of the *V. alfalfae, V. dahliae* and *V. longisporum* markers by testing on infected plant material. As proof of concept for the ability of the marker system to detect the pathogen in infected seed lots, project staff evaluated the sensitivity for testing infected seed for *V. alfalfae* and found 1 infected seed in 10,000 could be accurately detected.
- Genotype detection of *V. longisporum* - *V. longisporum* is a hybrid species with 4 different genetic lineages, A1, D1, D2 and D3. Some lineages can be more aggressive on particular hosts than others, so having a method for rapidly determining this could be useful. The cooperator's lab developed markers for doing just this.

Species in the genus *V.* have a broad host range but the work that was completed was focused on addressing the needs of the specialty crop industry.

The project partner in Canada did an excellent job of developing the marker system described in this project report. This included establishing a culture collection to support the project, sequencing the targeted regions of the genome from all 10 species, designing the genus and species specific detection capabilities, improving soil DNA extraction procedures, validating the marker system on a range of DNAs from cultures, soil and infected plant material and preparing DNA for genomic sequencing.

Goals and Outcomes Achieved

In order to achieve the project goal of developing species specific markers for additional *V.* spp. that are important to California specialty crops, the following activities were completed:

- The region used for designing the genus and species specific marker system was sequenced from a number of isolates representing the 10 *V.* species to allow for efficient design of primers and probes.
- Genus and species specific diagnostic assays were validated for all 10 described *V.* species.
- Soil DNA extraction techniques were improved and used to evaluate the relationship between soil inoculum density of the pathogen and readings from the TaqMan real time PCR assays.
- Genomes of the 9 *V.* species were sequenced by Illumina MiSeq in California and one using Ion Torrent PGM by the project collaborator, the mitochondrial genomes were assembled so comparative genomics could be used to identify regions for designing mitochondrial based genus and species specific diagnostic assays.

The long term goal of this project was to provide a reliable means for detecting and quantifying *V.* species from infected plant tissue and soil.

- While TaqMan real time techniques were validated, project staff would like to see the technology be transferred to the rapid RPA isothermal technology so assays could be conducted directly in the field.

Work in this objective was started as part of this project and will continue as part of other projects in the PI's lab.
- The marker system validated in this project is encoded in the nuclear genome, and having a second marker from the mitochondrial (a cytoplasmic organelle) would provide a complementary means for species identification. To develop a mitochondrial marker system the nuclear and mitochondrial genomes of representatives of all 10 *V.* spp. were sequenced and the mitochondrial genomes assembled.
- Comparative genomics was used to identify regions of the genome that would be useful for designing species specific markers. Work in this objective will continue as part of other projects in the PI and collaborator's labs.

The following were activities established to meet the project goals:
- Establish culture collection - completed
- Sequence loci used for developing species specific markers - completed
- Evaluate sequence alignments for marker design - completed
- Design primers and probes, test specificity - completed
- Confirm specificity with DNA from a range of *V.* species in California - completed
- Compare soil counts with real time PCR results to determine relationship between the two - this objective was completed for 16 soils with additional work with 22 soil in progress.
- Genomic sequencing of *V.* species and assemble the mitochondrial genomes - completed
- Design species specific diagnostic markers from mitochondrial sequences and validate - markers have been designed and work validating them is in progress
- Evaluate the ability of using the *V.* genus specific primers to amplify the target region from DNA extracted from soil to assess *V.* species communities - completed
- Evaluate the isothermal diagnostic technique recombinant polymerase amplification for utility in detecting *V.* spp. - technology was transferred but due to problems with the commercially provided kits there has been a delay in completing this work; it is currently in progress.

The following is the baseline data gathered:
- A culture collection of 210 isolates representing all 10 *V.* species has been assembled and DNA sequence data collected for design of the molecular diagnostic assays.
- A marker system for detection of all *V.* species at a genus specific level has been validated.
- Markers capable of detecting all 10 described *V.* species at a species specific level have been tested and validated.
- Validating these markers for quantification of the pathogen in the soil has been completed for 16 soils

The major successful outcome of this project was that a marker system for detection of all *V.* at a genus and species specific level was validated and tests completed indicate they will be useful for quantification of pathogen levels in the soil.

Goals and outcomes for this project were achieved.

Beneficiaries

In view of the broad host range of *V.* species (including many California specialty crops), the lack of genetic resistance of the host and the ability of pathogen inoculum to survive for a long time in the soil, the ability to rapidly and accurately quantify pathogen inoculum levels could have a meaningful impact on a wide range of California specialty crop producers by providing a management tool for making planting decisions. As an example, it is not possible to differentiate *V. dahliae* from *V. longisporum* on soil plates and while *V. dahliae* has over 300 hosts, *V. longisporum* is pathogenic on only 6 plant species. So a grower of a host of *V. dahliae* (eg. strawberry or lettuce) could be mislead into thinking it was not safe to plant when in fact the species counted on the plate could be *V. longisporum*, which is nonpathogenic on the crop they were going to plant. Likewise, *V. isaaci*, *V. klebahanii* and *V. tricorpus* cannot be differentiated by morphology, yet *V. klebahanii* is pathogenic only on lettuce, *V. isaacii* on lettuce, artichoke, tomato and spinach, and *V. tricorpus* has a slightly broader host range of 13 hosts including carnation, tomato and potato. Lastly, some species are not found in the United States (*V. zaregamsianum* on lettuce in Japan, *V. nubilum* on potato in the United Kingdom), so having tools to rapidly identify them would assist quarantine efforts to prevent the introduction and spread. In looking at the top 20 agriculture commodities for California in 2010, grape, strawberry, lettuce, tomato, pistachio, avocado, and celery are all hosts, and are widely planted in areas of the state conducive to disease development and have a combined value of over $10 billion.

The number of beneficiaries of this research would be hard to quantify, but would include all growers of specialty crops in California.

Lessons Learned

The following were the lessons learned by project staff as a result of completing this project:

- Optimization of soil extraction is very important for removing chemicals that can have a negative effect on the ability of molecular tools to detect the pathogen when present at low amounts. The work on this topic that was part of this project has improved the sensitivity of the assay, allowing detection when the pathogen is present in a low amount.
- Having a diagnostic assay that is capable of simultaneously detecting a pathogen at both a genus and species specific level and provides a systematic approach for developing species specific markers enhances the utility of the assay.

There were no unexpected outcomes or results that were an effect of implementing this project.

Additional Information

The Postdoctoral Researcher who worked in the project cooperator's lab left the position early to take a permanent position. Project staff are currently finishing up the data anlaysis of the Postdoctoral Researcher’s work and will be submitting manucripts describing the acomplishments of this research when this is complete.

- Some of this work was reported at the annual meeting of the American Phytopathological Society
  - Robideau, G.P., Martin, F. N., and G. J. Bilodeau. 2014. *Verticillium* wilt, but NOT by *Verticillium dahliae*: Accurate detection and identification of other important pathogens in the genus *Verticillium*. Phytopathology. 104 (Suppl. 3):S3.98.(Abstract) http://dx.doi.org/10.1094/PHYTO-104-11-S3.1

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 70	**Project Title:** Farm to Fork Specialty Crop Database – Phase 1	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12070	**Date Submitted:** December 2015
Recipient Contact: Elysia Fong	**Telephone:** 916-900-5189	**Email:** Elysia.fong@cdfa.ca.gov

Project Summary

Currently, a variety of state agencies, local governments, and community organizations encourage consumers and large food service institutions to be aware of and purchase from local specialty crop growers in their area. In most cases however, these programs suffer from disjointed coordination and are operating in silos—achieving marginal results in regional food access at the local level. In addition, large food service institutions, consumers and specialty crop growers also face barriers establishing sales relationships. These barriers include: proficient understanding of institutional procedures, local environmental health regulations, price points, transportation logistics, and lack of awareness of specialty crop availability, both geographically and seasonally. Additionally, the USDA's Farm to School census notes that on average, only 30% of California school district food budgets were spent on local food. This figure is only reflective of the 15% of California school districts that had information to respond to the survey. This is indicative of the lack of knowledge and resources available to School Food Authorities and School Food Service Directors about local specialty crops. In order to spend more of their budgets on local foods, School Food Service Directors need to be able to find and connect with local growers. However, because they are used to ordering through large distributors, more Food Service Directors lack the knowledge, time, and capacity to individually search for local growers who can meet their needs. Likewise, many specialty crop farmers traditionally sell to distributors or engage in direct marketing sales through avenues such as farmers markets or farm stands. Specialty crop growers, however, are often unaware of how to directly sell to institutional markets.

This project, the Specialty Crop Database (officially named the California Farmer Marketplace) sought to address those barriers by creating an online platform for specialty crop growers and schools to connect and initiate direct sales. By creating connections and making it easier for schools to find and purchase California grown specialty crops, the California Farmer Marketplace increases the marketability of California specialty crops and enhances specialty crop growers' ability to market their products and sell directly to schools.

Congress passed the Hunger-Free Kids Act in 2010 with bipartisan support to help ensure every American child had access to the nutrition they need to grow into healthy adults. One goal of the law was to help reduce America's childhood obesity epidemic and reduce health risks for America's children by helping schools across the country produce balanced meals so children had access to healthy foods during the school day. USDA based the new school meal standards on independent, expert recommendations from the Institute of Medicine to ensure kids are being fed healthy food while they are at school. One of the effects of the law was to increase the emphasis on farm to school programs. Farm to school programs typically emphasize procurement of locally grown food to include into school meal programs, as well as educational activities and school gardens. In California, there have been numerous initiatives to increase the amount of locally grown foods used in school meals. The project was conceived to help these efforts and increase the marketability of California-grown specialty crops by making them readily accessible to schools and emphasizing the importance of including specialty crops in school meals and farm to school programs.

This project was especially timely given the recent success and growth of one of these farm to school programs in California: California Thursdays. California Thursdays encourages participating schools to source an entire school meal from California grown products. The California Thursdays network expanded this year to 42 school districts serving over 250 million meals a year across the state. During the week of Earth Day, on April 23, 2015, the network celebrated California Thursdays in their districts by hosting fun, engaging events featuring fresh, California food and the people who grow it. The biggest barrier for schools participating in this program has been the time it takes to find California grown foods to use. Schools participating in this program have reached out to the Office of Farm to Fork for help sourcing California grown products. The Marketplace now provides a one-stop-shop for these schools to find California grown products and buy them directly from the farmers that grow them, expanding direct marketing opportunities for California specialty crop growers.

This project built on 2010 Specialty Crop Block Grant Program (SCBGP) Project 75: *Farm to Fork Website Development – Phase 1,* which funded the initial development of the Office of Farm to Fork website. The Specialty Crop Database, officially named the "California Farmer Marketplace," is available on the Office of Farm to Fork Website. The Office of Farm to Fork website has resources for schools and other consumers, including seasonality information and school-related resources (such as best practices and links to funding opportunities), but the addition of the California Farmer Marketplace (Marketplace) is a concrete tool that connects schools directly with specialty crop farmers in a way they have not been able to do before. The Marketplace provides an opportunity for specialty crop farmers to expand their direct marketing opportunities and connect with schools and other consumers through the Marketplace, which was not available before.

Project Approach

Project staff met with stakeholders to discuss their needs, the initial design of the Marketplace, and gather feedback to incorporate their suggestions and address their needs. As a result of meeting with school district food service directors in the two pilot counties to discuss their needs in procuring specialty crops directly from farmers, staff changed the initial design of the database to make it easier to search for specific commodities and not default to searching for specific growers. Staff also participated in helping six Contra Costa County school food service directors source products for the California Thursday celebration, which gave the staff firsthand experience of their procurement needs and processes. This information was brought back to CDFA Information Technology (IT) staff for implementation in the Marketplace design. Meetings with IT staff were held twice a month in the beginning with weekly meetings occurring as the programming progressed. Programming updates were typically pushed out once a week, depending on the changes requested. Once the main structure of the Marketplace was developed, staff reached out to stakeholders to register and gain their feedback on the process (for the first stakeholder to register, staff met in person to observe the process and take notes on ease/difficulty of the process to determine if any changes were necessary and suggest subsequent changes to IT staff). Additionally, staff worked with IT staff to develop a more generalized feedback mechanism to gather feedback from all parties using the Marketplace, which resulted in the default "Help us Improve" pop up all users see when exiting the Marketplace. This ongoing and default mechanism was determined to be the most effective way to survey all users to assist in gathering consistent feedback for both Phase 1 as well as Phase 2 of the Marketplace.

This project benefits both specialty crops and non-specialty crops. The project staff ensured that project funds only enhanced the competitiveness of specialty crops by obtaining additional funding to cover the non-specialty crops.

Since the Marketplace can house both specialty crops and non-specialty crops, staff needed a methodology to determine what share of the Marketplace would likely be specialty crops and what share would be non-specialty crops (and therefore require matching funds). Because of the minimal data at the outset, staff proposed using a roughly 60/40 split (specialty crop/non-specialty crop) in the initial grant proposal. This "known target threshold" is based on the farm gate value of specialty crops vs. non-specialty crops in California (60% of the state's farm gate sales comes from specialty crops as indicated in the California Department of Food and Agriculture's (CDFA) California Agriculture Statistics Review, 2013, with non-specialty crops making up the remaining 40%). Staff estimated that this would be a conservative split and predicted that specialty crops would benefit from more than 60% of the Marketplace. This estimate was based on a number of reasons, including the fact that some of the non-specialty crops (e.g. cotton, alfalfa, etc.) are not sold directly to schools and other consumers and therefore will not participate in the Marketplace. To ensure the integrity of SCBGP funds, staff obtained additional funds from the California Department of Education (CDE) and the California Department of Public Health (CDPH) to fund 40% of the development of the Marketplace.

As the Marketplace developed, it became clear that this 60/40 split was indeed a conservative one, with specialty crops accruing much more than 60% of the benefit of the Marketplace. Of the 454 different types of commodities farmers can post on the Marketplace, 389 of them are specialty crops and only 65 are non-specialty crops. By this count, 85.7% the Marketplace benefits solely specialty crops, and 14.3% benefits non-specialty crops, exceeding the minimum target of 60% specialty crops/40% non-specialty crops.

To date, 94% of the products available on the Marketplace are specialty crops. Although this number is subject to change as more farmers register on the Marketplace, staff anticipate that percentage of crops on the Marketplace will still be highly in favor of specialty crops.

To complete this project, staff needed input from the two main groups of users of the Marketplace: schools (specifically Child Nutrition Directors) and specialty crop farmers and their feedback was essential in designing the Marketplace. Additionally, the CDE, which administers the National School Lunch Program and the School Breakfast program in California, was an active partner in the development of the Marketplace. CDE was consulted and received a demonstration of the Marketplace as it matured. CDE also funded further development of the Marketplace to include non-specialty crops (see above) in order to help their stakeholders (school districts) source food for an entire school meal. The CDPH's Nutrition Education and Obesity Prevention Branch was also an active partner and was consulted, received a demonstration of the Marketplace, and also contributed additional funds. Both partners helped finance the Marketplace and attendance of project staff at association meetings to promote the Marketplace.

Goals and Outcomes Achieved

The Marketplace has been developed with the input of school food service directors and growers, as well as associated stakeholders. Discussions with the pilot schools led to important inclusions such as the growers indicating in their profiles whether they follow good agricultural practices (GAP) and on which crops, if they carry liability insurance and if so, how much, and if they offer ancillary activities such as farm visits. Input from school food service directors and other school stakeholders (e.g. CDE and the USDA Farm to School team) also lead to the development of the “compare” tool that can be used for school districts purchasing food through an informal bid process. [To meet USDA and CDE requirements, informal bids must show that the school district has looked at a minimum of three potential sellers. School stakeholders worked with staff to develop the “Compare” tool, which allows schools to compare different growers for selected items (e.g., if a school was interested in purchasing tomatoes, it can select three or more growers to compare and the Marketplace will display their information (including price, location/distance from school, food safety certifications and liability insurance) in an easy to use chart, which can be printed and filed to fulfill the informal bid requirement.)] On the grower end, staff included changes such as including seasonality of crops, appropriate size and type information.

Additionally, staff researched other online sites offering service for different types of items, and worked with IT staff to make sure that the Marketplace reflects features found in top online shopping sites, including multiple ways to select products and/or growers, numerous filters to narrow product selections, side-by-side product comparisons, pop up screens to facilitate navigation through the system, latest products added, products trending, a progress bar in registration, and the ability to contact the grower through the Marketplace.

The Marketplace was launched statewide at the end of June and followed by a statewide announcement from the California Secretary of Food and Agriculture.

The long term goal of this project is to increase access to and awareness of specialty crops to food service institutions and local community organizations. Progress towards this goal has been started through the creation of the Marketplace highlighting fruits, vegetables, and nuts grown in California and available for sale directly from the farmer. The Marketplace will provide the mechanism for these groups to find each other and begin to transact business. The evolution of the Marketplace will be driven by consumers and growers using the system and finding more ways it can meet their needs and increase the amount of California grown specialty crops in school meals.

The activities needed to achieve this long term goal include reaching out to farms in California that produce specialty crops and encouraging them to register and utilize the Marketplace as a means to increase sales to school districts and the community at large. The same is needed for school districts and other community members. This part of the process began with various demonstrations of the Marketplace and an announcement from the California Secretary of Food and Agriculture via targeted emails. Outreach was also conducted at the Small Farm Conference as well as at the California Farm to School Conference and other venues. Additionally, a button to access the Marketplace is prominently displayed on the Office of Farm to Fork website and the Marketplace is included as one of the banner topics on the website landing page. Staff will continue outreach and improvement efforts during Phase 2 of the project.

This project, Phase I of the Marketplace, was to create a database to be used by California school districts and growers to promote specialty crops in school meal programs. That database, the California Farmer Marketplace, is designed to facilitate school district food service directors finding and contacting farmers directly. It is also designed to aid small and medium size farmers in expanding their markets to large institutional customers. The accomplishments to fulfill this goal included reaching out to two pilot counties, Contra Costa County and Ventura County, for input. This information informed the creation and development of the Marketplace. The programming of the Marketplace was performed by IT staff with oversight by project staff. The Marketplace was to be released statewide at the end of this grant, June 30, 2015 and that deadline was met.

Unfortunately, the goal to have 10 school districts registered by June 30, 2015 was not met. Due to privacy policy issues, staff weren't able to allow people to register on the marketplace until later than anticipated. Additionally, during the initial meetings with stakeholders, the schools made it clear to project staff that they needed to have a number of farmers registered on the marketplace prior to having school districts register. So given both delays, staff were able to get eight school districts registered instead of 10.

For future tracking, staff are considering using data from USDA's Farm to School Census to measure the success in directing more school budgets toward local producers. Staff would have used USDA's data to measure long term progress, however it is currently being gathered by the USDA Farm to School Team and is not yet available publically. Staff have anecdotal data from the pilot counties showing increased purchasing of California specialty crops (e.g. the six most involved school districts in Contra Costa County have increased their local fruit and vegetable purchases). Staff have also received positive responses from the specialty crop community expressing appreciation of this new tool to help market their crops.

The Secretary of the CDFA sent out 515 emails throughout the State announcing the launch of the Marketplace. Recipients included a diversity of farmers as to size, crops, and processing abilities; school districts; County Farm Bureaus; County Agricultural Commissioners; Commodity Boards; State, County, and Local Government offices; and Food Banks and other nonprofits. Many of these recipients then alerted their contacts about the new opportunities the Marketplace is providing (for example, the Almond Board contacted staff about placing a notice in their newsletter to alert their growers as to how the Marketplace can benefit them). Additionally, the Marketplace launch was announced on CDFA's blog. The excitement in the agricultural community about the Marketplace speaks to its ability to increase the opportunities for farmers to access the school and institutional markets.

Beneficiaries

The primary groups benefitting from the project are California specialty crop farmers, who have a new tool to access and sell directly to schools, school districts that now have an easy way to find and purchase California specialty crops, and California school children, who will get to eat more California grown specialty crops as part of their school meals. The Marketplace is designed to help small to medium size farmers in particular access school markets, although all farmers have the ability to access the database and increase sales to schools. As stated above, on average, of California schools operating farm to school programs, only 30% of their food budgets were spent on local food. The Marketplace will provide a tool to increase that percentage and market California grown specialty crops in particular.

Because the California Farmer Marketplace is now available statewide, the potential number of beneficiaries and economic impact is huge. The Marketplace increases the marketability of specialty crops to California school districts and provides a direct avenue for sale of specialty crops to these schools. California schools spend more than $2 billion a year to provide school meals (California Department of Education 2013-14 school year). The California Farmer Marketplace has the potential to direct many of those funds directly to California growers. The Marketplace can benefit all of California's 45,646 specialty crop farms (USDA National Agricultural Statistics Services, 2012 Census of Agriculture, Specialty Crops) by providing them a new way to sell their products directly to consumers.

Lessons Learned

The delay in the launch of the database to the pilot counties created a need to capture feedback as expediently and conveniently as possible. As a result, a "Help Us Improve" dialogue box was designed that pops up every time a user logs out to provide the opportunity for immediate feedback. This method of collecting user responses not only helped staff gather user feedback during this phase of development, but will also carry forward into Phase 2 and provide an consistent method of surveying users about the experiences. All of the feedback is directed into an email account, which is then chronicled in a spreadsheet for staff review and discussion with IT programmers.

Another lesson learned was the importance to school districts in having a commodity driven design. Staff initially designed the Marketplace to default to a search for farmers, where schools would search for growers based on things such as liability insurance, food safety certifications, and distance, and the result would show which farmers in their area met their requirements. However, the feedback from schools in the pilot counties was to make the search more commodity specific to fit their needs because schools generally are searching for specific items to include in the menus. Staff then worked with IT programmers to change this, so the default search is commodity based – schools can go on and search for a specific commodity and then see which growers meet their specifications. For example, schools can look for cucumbers, grown on a farm that is GAP certified with a minimum liability insurance and see a list of cucumber growers that meet those requirements (as well as information on price, distance, etc.), and then send inquires to the growers from there. Staff decided to retain the farm-based search function as well, but made the commodity search the default design.

The Marketplace was initially conceived to address the growing farm to school movement in California and overcome the barriers that schools and farmers face in working together. During the course of the Marketplace development and discussions with stakeholders, however, it became clear that other consumers also wanted the ability to connect directly with farmers and that specialty crop farmers were eager to expand their direct marketing opportunities to them as well as to schools. While maintaining the school-centered design, staff aren't limiting the Marketplace to schools – instead making it publically available to anyone who wishes to use it to search for California grown products. Already, individuals and restaurants have registered on the Marketplace as well as schools.

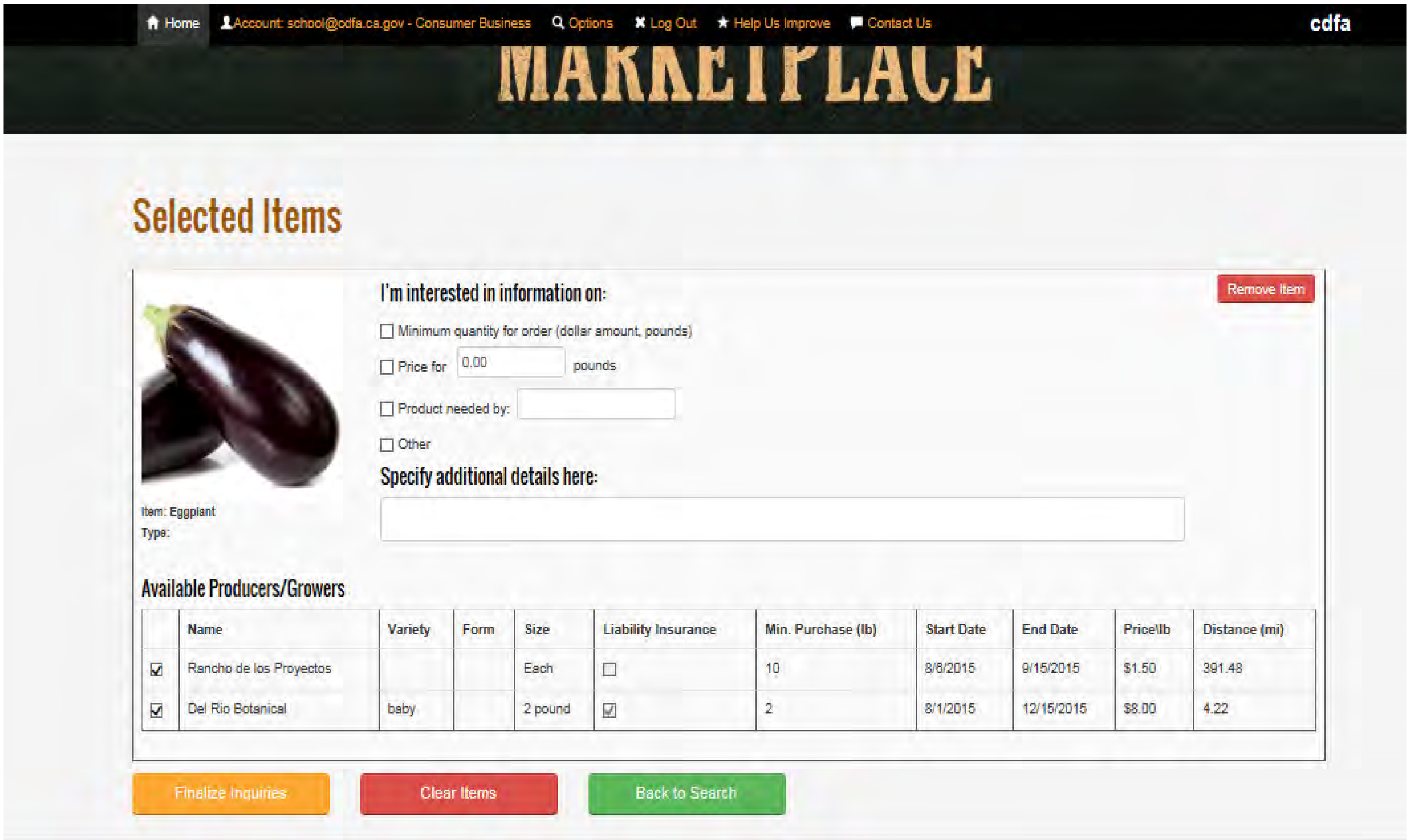
The design and development of the Marketplace took longer than anticipated due to an effort to give the end user as intuitive and familiar a shopping experience as possible. As this was a new project not built upon a previous database, the first design proved not to be the best. Users requested a more "commodity driven" design and it took several efforts to find the best approach. The original design was deemed too cumbersome and didn't give the user the maximum flexibility desired.

As a result of the database development taking longer than anticipated, the launch date to the pilot counties had to be pushed back. It was planned that the pilot counties would utilize the database for six months to give feedback and evaluate the database performance. However, staff truncated the pilot counties' feedback activities in order to meet the statewide launch date. Staff will continue to collect feedback from all users of the Marketplace going forward into Phase 2.

Additional Information

The Marketplace is available at www.cafarmermarketplace.com or via the Farm to Fork Website, www.cafarmtofork.com

Below is an example of the “Compare” feature, showing two of the eggplant growers registered on the Marketplace:



USDA Project No.: 71	**Project Title:** Growing California Video Series	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12071	**Date Submitted:** December 2015
Recipient Contact: Josh Eddy	**Telephone:** 916-654-0462	**Email:** Josh.eddy@cdfa.ca.gov

Project Summary

This project branded the image of California specialty crops within the social media sector to raise awareness on the diversity, innovation and scope of the state's food system. Specifically, this project addressed increased consumer interest in the food system (regional, local, and organic) and leveraged that interest to educate the consumer and market California specialty crops.

This project is important and timely, as consumer interest concerning the food system has increased dramatically in recent years. The goal of the project was to create a favorable disposition and impression of specialty crops for consumers, because consumers with a favorable disposition to a product are more likely to purchase that product, which enhances the overall competitiveness of the industry.

This project built upon 2010 Specialty Crop Block Grant Program (SCBGP) Project 11: *Engaging Social Media – The Voice of California's Specialty Crops* and 2011 SCBGP Project 79: *Growing California Video Series*. This grant Proposal complements the previous work on this project by continuing to expand on the foundation of market enhancement and consumer awareness already accomplished through earlier videos. These previous videos have proven to increase consumer engagement through social media metrics employed previously and have been utilized by CDFA, the Buy California Marketing Agreement (BCMA) - CA Grown, and other stakeholder groups to increase engagement and interest regarding specialty crops. A total of 44 videos have been produced which highlight a diversity of specialty crop products. Videos produced under this project continue to highlight un-featured specialty crop products and on-farm practices/events. The quantifiable long-term effects of these videos have been increased consumer awareness manifested through a rise in social media engagement and interest in CDFA's Planting Seeds Blog as well as viewership on the CDFA YouTube channel, CDFAtoday. Long-term, these rising levels of engagement will magnify with the presence and effectiveness of additional videos.

Project Approach

The Growing California Video Series was produced from March to September 2015. The project resulted in the production of eight video pieces on California specialty crops. Social media promotion of the videos began in April and will conclude in December 2015. The social media release schedule coincides with the production/finalization of a video and an additional final social media push for the series will occur (October – December 2015) that incorporates the online video survey.

CDFA contracted with California State University, Sacramento's Academic Technology and Creative Services (ATCS) division to accomplish the production/editing of the Growing California videos. CDFA's project manager worked directly with ATCS over the grant period to achieve project deliverables. CDFA's Office of Public Affairs managed the social media program which consisted of survey implementation and data tracking.

The social media program of the project was augmented to delay the online survey until all videos had been completed. This delay was decided to best enhance program results through a targeted social media push that would occur following the completion of all videos. (October – December 2015). This social media push would include the partnership with BCMA, a project partner in the activity, who assisted with video topic selection, social media messaging, and promoted the release of the videos. In addition to the online survey, traditional social media metrics have been collected for the produced videos during the project time period.

The focus of each Growing California video was on an individual/multiple specialty crop(s) or program that specifically focused on eligible specialty crops.

Goals and Outcomes Achieved

The Growing California Video Series consisted of eight videos focusing on specialty crops. The goal of the project was to increase consumer awareness of specialty crops, specialty crop farmers and their products through the social media sector. Produced videos were various social media outlets including Twitter, Facebook and YouTube.

	Videos	Activity Completed:	Social Media Publication:
1.	Strawberry Fields	April 2015	April 2015
2.	Water Wisdom	May 2015	May 2015
3.	Small Potatoes	June 2015	June 2015
4.	Drought Landscaping	July 2015	August 2015
5.	Gilroy's Garlic	July 2015	July 2015
6.	Nature's Candy	August 2015	September 2015
7.	Growing Together	September 2015	Fall/Winter 2015
8.	Farm to Folks	September 2015	Fall/Winter 2015

The outcome measure for the project was based on results of the online survey. This would be the first year for an online survey metric.

Target: 300 responses/ 50 percent positive response on identified performance measures

Performance Measure #1 - Increased awareness of California specialty crops (Yes/No)
Performance Measure #2 - Inclined to purchase after viewing videos (Yes/No)
Performance Measure #3 - Best benefits of purchasing (multiple selections)

While the videos have been launched on social media, the online survey tracking took place between October – December 2015. This delay in social media metric collection allowed for a short re-release of videos on social media platform, which staff hoped would improve the survey response rate allowing the metrics to be captured for all created videos at one time. However, the results for the online survey metric, embedded within the videos, failed to reach the target goal of 300 responses. The overall response rate was less than 5 percent of the target and results are therefore inconclusive.

Other social media metrics for the series are provided below. Baseline social media metrics are taken from 2014 baselines.

Growing CA Viewership: (April to September 2015) 6 videos

Planting Seeds Blog:	1909 views	(Per video average 318 views)
Buy California YouTube:	3892 views	(Per video average 648views)
CDFA YouTube:	734 views	(Per video average 122 views)
Facebook:	1409 views	(Per video average 234 views)
Total views:	7,944 views	(Per video average – 1,324 views)

Social metrics, demonstrating progress on identified outcomes are listed above. In addition, social media impressions on twitter for the Growing California Video Series for the reporting period were more than 12,000.

In comparing the Growing California Video Series to baseline data from the previous project the following data is available.

Total 2015 views:	7,944 views	(Per video average – 1,324 views)
2014 Baseline	8,249 views	(Per video average – 824 views)
2015 Results	(- 3%)	(+ 60%)

Based on average per video viewership, the Growing California videos for the current project period increased viewership by and estimated 60 percent.

The video production aspects of the project have been completed showcasing the diversity, innovation and scope of the state's food system in relation to specialty crops. The project continues to provide awareness on California's diverse specialty crop industry and the farmers that grow the food. This awareness does provide a favorable disposition of consumers to California specialty crop farmers and their products, enhancing the overall competitiveness of the industry. Produced videos have been shared by agricultural organizations, outside of current social media tracking, that also expands outreach to the public.

Beneficiaries

California's 45,646 specialty crop farms (USDA National Agricultural Statistics Services, 2012 Census of Agriculture, Specialty Crops) are the direct beneficiary of this project. Statewide more than 33,470 farms or 43 percent (including specialty crop) have less than $10,000 in sales (market value). By increasing the visibility and awareness of California specialty crop products, this project is increasing the potential for consumer purchases.

Lessons Learned

The Growing California video series provided an opportunity to highlight the diversity of specialty crops within the state.

Positive Results of Program:

- An increase in consumer awareness concerning California specialty crops. This awareness will further improve the competitiveness of the specialty crop sector.
- More than 7,900 views and 12,000 impressions of the Growing California video series on social media.
- Production of eight Growing California videos

Observations/Recommendations:

- Social media marketing is an effective means to increase consumer awareness. Improved social media performance (metrics, tracking and promotion) can be achieved through contractual activity and should be considered for future projects to maximize visibility and consumer reach. This did not occur in 2015 because of cost considerations.
- Metrics for a consumer awareness campaign are difficult to achieve without significant investment in pre/post research. This further validates the need for professional social media marketing services.
- Cooperation with agricultural organizations was highly successful in determining video subjects and focus. Any future or similar projects would should include joint cooperation with agricultural stakeholders.
- Complete outsourcing of video production is not recommended because of the complexity, diversity and uniqueness of the agricultural sector.
- Online surveys, embedded within produced videos, are difficult to achieve target response rates as a measure of performance. Future projects should base metrics on standard social medial performance measures.

By implementing the social media campaign internally versus through a contractor, delays resulted in incorporating an online survey component within individual videos. While the outcome measure was tracked and evaluated toward targeted goals, the delay did push back outcome reporting. The project was able to move forward promoting videos on social media and tracking standard social media data, but without the survey in place. The low response rate on embedded video surveys was not anticipated. While other performance metrics were used to evaluate the success of the project, the embedded survey approach will not be used on future projects.

Additional Information

Growing California Videos can be seen/referenced on the following websites:

- CDFA Website - http://www.cdfa.ca.gov/
- CDFA Planting Seeds Blog - http://plantingseedsblog.cdfa.ca.gov/wordpress/
- Buy California Marketing Agreement - http://www.californiagrown.org/growing-california/
- Youtube (CDFA) - https://www.youtube.com/channel/UC96Fqn_OMC907uCEd_23f5A
- Youtube (BCMA) - https://www.youtube.com/channel/UCDmo1-rMeWcwNX10P_41Duw

USDA Project No.: 72	**Project Title:** Increasing the Capacity of the Plant Pathology Laboratory for Phytosanitary Testing of Specialty Crops	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12072	**Date Submitted:** December 2015
Recipient Contact: Cheryl Blomquist	**Telephone:** (916) 262-1870	**Email:** Cheryl.Blomquist@cdfa.ca.gov

Project Summary

Thousands of samples per year are tested by the Plant Pathology Laboratory for phytosanitary quarantine purposes. Field inspections, fungal or bacterial isolations and pathogenicity tests allow seed and nursery stock produced in California to be cleared for export to foreign markets. The agricultural economy of specialty crops produced in California is worth $44.7 billion dollars with agricultural products sold to foreign markets the most rapidly growing segment. This means the number of phytosanitary certificates written for specialty crop product export has increased and is predicted to continue to increase. Increasing the capacity of the Plant Pathology Laboratory to conduct such testing related to the movement of specialty crops in commerce will increase/ improve California growers' ability to access international markets.

If a disease is detected in the inspections, it is necessary to prove the fungal or bacterial organism caused the disease. This is reproducibly done in a dew chamber and followed by grow out in an environmentally-controlled growth chamber. Once inoculated, plants need to be maintained under a controlled environment with high humidity in order for disease to be confirmed. The lack of controlled environmental conditions makes it difficult to simulate disease-causing conditions, and pathogenicity tests in the lab have to often be tried several times before being successful due to the difficulty in controlling the environment in these old chambers with makeshift enhancements. A more precisely controlled modern growth chamber will allow us to create correct environmental conditions the first time, and not require test to be redone, thus saving money and improving turnaround time. The precision of the new equipment will make the tests more repeatable and consistent. For environmental safety, State and Federal (USDA) permits for diagnostic testing require the laboratory to perform pathogenicity tests in a growth chamber.

This project was not built on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Following the procurement process, the growth chamber was ordered on September 14, 2015. However, the equipment has not been received yet.

This project solely enhances the competitiveness of specialty crops. Only specialty crops will benefit from the use of equipment. The vast majority of work in any of the current growth chambers is done on specialty crops. In the small number of cases where a crop from another category is being inoculated, another growth chamber not purchased with Specialty Crop Block Grant program funds will be used. The new growth chamber will be designated and used for specialty crops only, with a sign “For specialty crops use only” on the growth chamber.

Goals and Outcomes Achieved

While the procurement process to acquire the instruments was completed on September 14, 2015, the equipment has not yet been received so performance goals and outcomes have not been achieved. There is a delay in the equipment shipping and shipment is expected in early February 2016. After installation of the equipment is complete, training on use of the new chamber will be completed, then pathogenicity experiments will begin with the new equipment.

Beneficiaries

A new environmentally contained growth chamber will enhance the consistency and reproducibility of the detection and identification of plant pathogens for specialty crop fruit, nursery stock, and vegetable seed crops, and improve California growers' ability to access international markets.

This project benefits the nursery industry and specialty crop fruit growers. The Agricultural Council of California has more than 15,000 grower members, and this project will potentially benefit these members. In addition, there are 4,139 farms in the nursery, greenhouse and floriculture category in California which will potentially benefit from this project (USDA National Agriculture Statistics Service 2012 Census of Agriculture, Specialty Crops).

This equipment is a onetime purchase and will not require continuing funding. Once installed, this equipment will continue to benefit the California specialty crop industry for many years beyond the grant period.

Lessons Learned

Ordering specialized equipment took longer than expected.

Additional Information

None.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 73	**Project Title:** Improving the Capability of Specialty Crop Pesticide Residues Analysis	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12073	**Date Submitted:** December 2015
Recipient Contact: Tiffany Tu	**Telephone:** 916-228-6830	**Email:** Tiffany.tu@cdfa.ca.gov

Project Summary

The California Department of Food and Agriculture's Food Safety (FS) laboratories at the Center for Analytical Chemistry (CAC) screen domestic and imported specialty crop produce for all classes of pesticides and herbicides to assure the quality and safety of California's food supply. The Pesticide Residue laboratories (PR) have a 24 hour turnaround obligation to submit analytical results of the specialty crop samples to Enforcement agencies so they can quarantine crops that contain tolerance violations or would pose a health risk for consumers. To be effective in its goal of providing timely, accurate and relevant results to enforcement and surveillance agencies, PR laboratories must rely on rugged and sophisticated instrumentation. The Anaheim laboratory received a previous Specialty Crop Block Grant Program grant to purchase a Quantiva Liquid Chromatograph-Tandem Mass Spectrometer (LC-MS/MS). The Anaheim PR laboratory utilizes the LC-MS/MS instrument to screen for over 220 pesticides on domestic and imported specialty crops. If a violation is detected during the normal screen, laboratories must reanalyze the violative samples to confirm the finding. Having one main instrument for both detection and confirmation process impedes the workflow as the normal sequence must be disrupted to allow for the confirmation process which delays samples turnaround time. Providing the Anaheim laboratory with an additional Quantiva LCMS/MS system allows staff to conduct assays, analyze data and perform violation confirmation concurrently for uninterrupted laboratory operation which translates to time saving and improves the overall system quality.

The PR laboratories monitor for agro-chemicals in specialty crops to ensure their safety and to prevent potential pesticides misuse. Supplying the Anaheim lab with the new Quantiva LC-MS/MS allows the expansion of the current screening method to detect more agrochemicals, development of faster screening, confirmation and data reviewing methods, and improvement of data accuracy. These endeavors enhance the competitiveness of California's specialty crops as the results clearly demonstrate the safety of California grown produce. Having an additional Quantiva instrument enables uninterrupted work process for faster submission of data results. A larger scope, more efficient process and quality data will be achieved with this project.

This project built upon 2011 Specialty Crop Block Grant Program Project 82: *Improving the Capability and Data Defensibility of Specialty Crop Pesticide Residues Analysis.* The 2011 project allowed the Sacramento laboratory to purchase a LC-MS/MS to improve its monitoring capability and develop better analytical methods. The 2011 project also the Anaheim lab to purchase a LC/MS-MS to improve and expand the testing capability of the Anaheim laboratory. This project will allow the Anaheim laboratory to improve its monitoring capability and utilize the analytical methods developed in the Sacramento laboratory. Staff will be able to conduct assays, analyze data and perform violation confirmation concurrently for uninterrupted laboratory operation which translates to efficiency and overall system improvement.

Project Approach

Following the procurement process, the equipment was ordered on September 15, 2015. The equipment was received, and installation will be completed by the end of 2015.

This project solely enhances the competitiveness of specialty crops. The use of the equipment will be monitored by the Food Safety-Pesticide Residue Program to ensure it is used solely for screening pesticides and other agrochemicals on specialty crops.

Goals and Outcomes Achieved

While the procurement process to acquire the instrument was completed on September 15th, 2015, the equipment has not been installed. However, scientists at the Anaheim PR laboratory conducted method development and validation on the existing Quantiva, and the method is fully implemented. Once installation is complete, instrument verification, method transfer and implementation will be completed.

With the existing LC-MS/MS, the Anaheim laboratory was able to enlarge the screen list by 17% and data quality improved because of instrument's superior sensitivity. When the additional LC-MS/MS is installed and fully implemented, it will serve as the confirmatory instrument. This operating scheme will enable faster turn-around time in submission of data results to enforcement agency because there is dedicated instrument readily available for the confirmation process. Currently, there is only one unit for both screening analysis and confirmation purpose.

The Anaheim PR laboratory staff was successful in adding more than 50 agrochemicals to its screening list using the Quantiva procured from 2011 Project 82. Some of the newly added compounds are pesticides with new chemistry that would not have been detected using the traditional detectors. The Quantiva, with its special accessories, can potentially shorten analysis time more than 50%. The team sets the new analysis time at 70% current rate (14 minutes per cycle vs. 20 minutes). For the future, PR team hopes to develop a 10 minute analytical run on this new instrument system. This will decrease samples turnaround time much more. With full implementation of the new Quantiva instrument and software system, the Anaheim PR laboratory will increase its effectiveness and efficiency in monitoring for chemicals on specialty crops.

Beneficiaries

The specialty crop industry will benefit from the project as the PR laboratories' surveillance data clearly demonstrate that California specialty crops are safe, enhancing the value of California's specialty crops. There are 45,646 farms in California producing specialty crops with a market value of $30,451,932,000 [USDA National Agricultural Statistics Service, 2012 Census of the Agriculture, Specialty Crops] that will potentially benefit from this project. The California consumers also benefit as they can be assured their food supply is being monitored for harmful agrochemicals such as pesticides.

Lessons Learned

None.

Additional Information

None.

USDA Project No.: 74	Project Title: Acquisition of stereo and compound microscopy for specialty crop pest and disease identification training.	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12074	**Date Submitted:** December 2015
Recipient Contact: Stephen Gaimari	**Telephone:** 916 262-1131	**Email:** Stephen.gaimari@cdfa.ca.gov

Project Summary

The funding requested was for the purchase of 20 training microscopes (10 stereo, 10 compound) to facilitate diagnostics training for specialty crop diagnosticians and clientele. The equipment purchase will enhance the ability of the CDFA Plant Pest Diagnostics Center (PPDC) to provide requested training to various specialty crop constituencies from all labs (Plant Pathology, Nematology, Entomology, Seed Science, and Botany). Specifically, this equipment will allow diagnostic protocols to be practiced and learned in a hands-on approach, using real specialty crop pest samples. This, along with demonstrations, is a superior mode of teaching diagnostics than using Power Point© presentations, because of the hands-on, real-time component. The PPDC routinely receives requests for training on diseases and pests of California's full array of specialty crops, from half-day workshops to larger, multiple-day sessions, for groups of varying sizes. These include training: (1) CDFA staff (e.g., border station, field, technical) to recognize or screen pest groups to better focus survey and exclusion efforts and to promote more timely diagnostics of potential pests of all specialty crops; (2) scientific personnel from California counties to enhance their diagnostics ability, provide training in certain techniques or recognition of specific pest groups affecting specialty crops; and (3) industry and commodity associations and groups (e.g., seed technologists, Citrus Research Board) to enhance abilities of professional diagnosticians as well as screeners and field personnel dealing with specialty crops.

The acquisition of training microscopes will enhance PPDC's ability to fill a critical gap in professional training for specialty crop diagnosticians and clientele. The trainings will: (1) increase the knowledge base and abilities of trainees with respect to pests and diseases that affect California's specialty crop industry; (2) raise awareness of the movement of new pests and diseases in the plant and nursery trade, in other agricultural commodities, and non-agricultural products to more quickly mitigate pest problems as they arise; (3) promote early detection and recognition of potential pests; and (4) raise awareness of quarantine and plant health regulation requirements. In a recent article in Plant Disease 93:1228-1237, the authors describe that due to demographic trends and lack of courses in universities, the number of diagnosticians will not keep up with the demand.

This project builds upon previous 2010 Specialty Crop Block Grant Program Project 72: *Acquisition of stereo and compound microscopy for specialty crop pest and disease identification training*. Under the previous grant, two teaching microscopes (one stereo, one compound) fitted with camera attachments and dedicated digital camera setup were acquired, as well as a dedicated computer for their use. This equipment allows trainees to observe demonstration of diagnostic protocols and displays actual specialty crop pest samples on screen in real-time. This project directly complements the previous grant as it provides the microscopy for hands-on training activities, allowing the trainees to benefit directly from use of a microscope to directly learn and practice screening and diagnostics techniques, in addition to watching and observing on a screen.

Project Approach

Following the procurement process, purchase of ten compound and ten stereo microscopes was completed. Also, the purchase and installation of a cabinet to safely house the microscopes was completed.

With the importance of specialty crops to California agriculture, and the pervasive training needs for people dealing with specialty crops, this project is solely for the benefit of the specialty crop industry. PPDC management will oversee the use of the equipment and will ensure that utilization is solely for the benefit of the specialty crop industry in California. Equipment use will be monitored by PPDC staff through implementation of a training record database to ensure benefits only accrue to California specialty crops.

Goals and Outcomes Achieved

Purchase of ten compound and ten stereo microscopes was completed. The purchase and installation of a cabinet to safely house the microscopes was also completed. Arrangements were made for the manufacturer representative to unpack and install all the microscopes to make sure everything functions properly. This took place in November 2015.

Purchase of the microscopes is crucial to the long-term success of the project beyond the funding period. Since the microscopes have been installed, enhanced hands-on training can begin for: (1) CDFA staff (e.g., border station, field, technical) to recognize or screen various pest groups to better focus survey and exclusion efforts and to promote more timely diagnostics of potential pests for all specialty crops; (2) scientific personnel from California counties to enhance their diagnostics ability, provide training in certain techniques or recognition of specific pest species and groups affecting specialty crops; and (3) industry and commodity associations and groups (e.g., seed technologists, Citrus Research Board) to enhance abilities of professional diagnosticians as well as screeners and field personnel dealing with specialty crops.

The first phase of the work plan, purchasing the equipment, has been completed. The second phase began with two training sessions conducted in November and December 2015. No specific data was collected on the effectiveness of these two trainings as the surveys are in the process of development; however, both training sessions were well received and acknowledged.

On November 19, 2015, the microscopes were used for requested Master Gardener training by CDFA Entomology and Plant Pathology staff. There were about 48 participants split into three groups. For the Entomology and Plant Pathology sessions, both the stereo and compound microscopes were used, with stations for everyone to sit down and peer through the microscopes and manipulate the specimens. In the Plant Pathology portion of the training the participants looked at spores and fruiting structures of Colletotrichum species under the stereo and compound microscopes. They learned the basics on how to tell a leaf spot caused by a fungus from those caused by environmental factors. Plant roots were also examined and the characteristics of healthy versus diseased plant roots were discussed. In the Entomology portion of the training, the participants observed and manipulated the following pests: light brown apple moth (Epiphyas postvittana), Japanese beetle (Popillia japonica), Asian citrus psyllid (Diaphorina citri), spotted winged drosophila (Drosophila suzukii), brown marmorated stinkbug (Halyomorpha halys) and glassy winged sharpshooter (Homalodisca vitripennis). Both adults and immatures were shown, either pinned or in a dish of alcohol under the microscope for each species. Basics of identification of each species were discussed, along with typical plant damage and common host plants relevant to the Sacramento area. Every participant was given time to view both the immature and adult stage of each species under the microscope and have questions answered.

On December 8, 2015, a training course for eight Border Station employees was conducted. These eight staff will also be bringing what they have learned to train new staff at the Border Stations. The training included hands-on work with the stereo microscopes on insects and seeds of regulatory concern for specialty crops in California. In particular, the training focused on insect pests of honeybees, fruit and nut trees, as well as ornamental and nursery plants. Weed seeds that are problematic for many fields and orchards where specialty crops are grown were also observed using the microscopes. The training of Border Station personnel on these pests reduces the threat of invasive species from entering and establishing on California's specialty crops by increasing awareness of these pests entering the state through the Border Station network. This training resulted in updates to the Border Station Manual based on the presentations and demonstrations.

Beneficiaries

Acquisition of the equipment necessary for enhanced training from PPDC staff makes the training better quality and more comprehensive, and teaches the hands-on approach that the trainees will be using directly. The beneficiaries are the specialty crop agricultural industries in California, as they are the beneficiaries of better trained people serving the industry. There are 45,646 farms producing specialty crops on 4,338,625 acres in California (USDA National Agriculture Statistics Service 2012 Census of Agriculture, Specialty Crops).

The specific benefits to the specialty crop industry include better educated field and lab staff who will be able to recognize pests of specialty crops earlier and more efficiently. This facilitates a faster pest mitigation response, preventing the far more costly control and/or eradication efforts that would result from an invasive well established pest population. This benefits both the growers in terms of reduced crop damage, and the exporters in terms of being free of pests that importing countries/states do not allow.

This project will also have beneficial impacts on multiple groups, including specialty crop field and diagnostic staff, industry and commodity groups (e.g., seed technologists, Citrus Research Board, Certified Nurserymen, horticulturalists, growers, farm advisors) who request training. PPDC scientists are often called upon to provide specific trainings, and acquisition of this equipment will facilitate the ability to provide it, and make for a more comprehensive and effective educational training experience.

An example of how more effective training will benefit the specialty crop industry is the federal phytosanitary preclearance program for citrus shipments to Australia. Growers, shippers, exporters, regulatory officials and overseas buyers rely upon international food quality and pest free cleanliness standards to move California citrus exports. Preclearance phytosanitary standards are often changed without notice, with new pests added to the preclearance program. In one instance (citrus), the PPDC was unable to provide real-time hands-on pest identification training to citrus commodity field and lab staff for these new pests which resulted in delayed shipments. These delays resulted in losses to the shipper of at least $22,750 for the spoilage of each shipping container of fruit. California Citrus Mutual (CCM), the trade organization representing California citrus growers, packers and shippers, expressed concerns that unreasonable delays are unacceptable for a commodity (fresh oranges) that was awaiting export and is perishable. CCM also stated that the world export markets are highly competitive and if an overseas buyer cannot obtain the commodity within a specified time period, the buyer will pursue another supplier, and the export market for California growers will be lost. This project will allow the PPDC to provide the real-time hands-on training to avoid similar losses.

Lessons Learned

None.

Additional Information

None.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 75	**Project Title:** Enhancing Diagnostic Capabilities of the Nursery Stock Registration and Certification Program at the Plant Pest Diagnostics Center – Accuracy and Throughput	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No.:** SCB12075	**Date Submitted:** December 2015
Recipient Contact: Duane Schnabel	**Telephone:** (916) 654-0312	**Email:** duane.schnabel@cdfa.ca.gov

Project Summary

Nursery stock registration and certification programs protect specialty crops such as grapes, fruit trees, and citrus from the spread of economically harmful plant pests and diseases by providing testing and inspection services for registered and certified plants. By improving the confidence of cleanliness for targeted plant pathogens and pests, the program helps to limit economic loss, protect the environment, and ensure the global competitiveness of specialty crop producers.

Recently, new technologies have led to the discovery of pathogens that were previously not detectable, such as the discovery of Grapevine red blotch-associated virus in 2012. In addition, new molecular testing protocols are being developed that are faster and more effective in detecting known harmful pathogens. The purchase of new laboratory equipment is necessary to meet these expanding testing demands. By improving the laboratory's diagnostic capability, speed, and capacity, the needs of the specialty crop producers, as well as critical federal and state enforcement, will be met. The purchase of a nucleic acid purification system and a real time polymerase chain reaction (PCR) system will improve diagnostic workload capability and high capacity throughput.

This project does not build upon a previously funded Specialty Crop Block Grant Program project.

Project Approach

Following the procurement process, the equipment and supplies were ordered. The freezer, analytical balances, real time PCR, PCR work station, dead air box, nucleic acid purification system, and bio-security hood, micro-centrifuge were received and installed in the PPDC Laboratory. The accessory supplies (pipets, PCR rotor, gel kits, and vortex mixer were received and placed into operation. Unique methodologies and protocols for high capacity DNA extraction and PCR diagnostics for Grapevine red blotch-associated virus (GRBaV) were developed and implemented. A tracking database for sample diagnostics evaluation to confirm progress towards goals and benchmarks was developed. Data collection and quality control assurance of data was initiated and continues. All of the equipment was calibrated for accuracy and the protocol methodology certified.

This project solely benefited specialty crops. The Nursery Stock Registration and Certification Program tests for pests and diseases that affect specialty crops such as grapes and deciduous fruit and nut trees.

Goals and Outcomes Achieved

The goal was to reduce the amount of time needed to detect diseases in registered plants in order to increase the number of samples tested per week. Increasing the capacity of the laboratory increases the specialty crop growers' ability to appropriately respond to plant disease detection in a more favorable timeframe in order to prevent crop damage by reducing the amount of time needed to detect plant diseases. Prior to installation of new equipment, testing for GRBaV could be performed using manual extraction of nucleic acid and conventional PCR at a rate of 100 samples per week. With the implementation of Kingfisher Flex Nucleic acid purification system and QuantStudio 6 Real time PCR system and associated laboratory equipment and supplies, the testing capacity has been increased to an estimated 600 samples per week. Further increase of testing capacity up to 1,200 samples per week will be possible with additional personnel.

The addition of the AirClean System and Dead Air Box increases capacity for the processing of red blotch, leafroll, fanleaf, and tomato ringspot plant samples by diagnostic technicians. These diseases affect specialty crops. After the initial sample processing, plant tissue samples are handled in groups of 96 for DNA extraction and PCR testing. The 96-well DNA extraction and PCR testing methodology protocol was developed with the new equipment acquired under this grant, and requires fewer diagnostic technicians than previous protocols. The new freezer will increase and accommodate the storing capacity for the plant DNA extracts needed for PCR testing.

The current lab capacity for DNA and PCR testing increased by 600%.

Beneficiaries

The immediate direct beneficiaries of the increased laboratory testing capacity are the California Grape Industry. Secondarily, additional resources are now available for conducting analyses on other plant pathogens such as Grapevine leafroll-associated viruses, Grapevine fanleaf virus, Prunus necrotic ringspot virus, Tomato ringspot virus, Prune dwarf virus, and all plant pathogens of specialty crops. The project will enhance the overall capabilities of the Plant Pest Diagnostics Center laboratory, making plant pathogen testing more efficient; thus providing additional resources and service to California's entire specialty crop industry. There are 5,900 wine grape growers, 510 table grape, 1,750 nut tree and 225 fresh tree fruit growers in California will benefit from this project.

The impact of a single plant pathogen can be devastating to California specialty crops. For example, a 2012 study in the Finger Lakes region of New York found direct economic losses from Grapevine leafroll-associated viruses (GLRaV) estimated at between $25,000 and $40,000 per hectare (Atallah, S. S., et al., Economic Impact of Grapevine Leafroll Disease on Vitis vinifera cv. Cabernet franc in Finger Lakes Vineyards of New York, American Journal of Enology and Viticulture, March 2012, vol. 63 no. 1, 73-79). Since its discovery in 2012, GRBaV has been found in all major grape-growing areas in the United States. While its economic impact is still being studied, GRBaV could have a dramatic impact on the estimated over $5 billion/year California Grape Industry. According to USDA National Agricultural Statistics Services, California is the top grape-producing state in the nation; California's grape acreage in 2014 totaled approximately 928,000 acres.

Lessons Learned

DNA and PCR protocol development is very complicated. A step by step approach using state-of-the-art equipment, coupled with scientific staff with expertise, was needed to accomplish the task. There were many technical obstacles and staffing limitations to overcome. Although laboratory testing capacity was increased with the addition of new equipment and methodology/protocol development, this capacity has not yet been fully tested. By the next testing peak season (Fall/Spring), the laboratory will have the opportunity to demonstrate the full value of this new equipment. Although knowledgeable and expert technicians are employed at the laboratory, the time required for training on new lab equipment was greater than anticipated.

Additional Information

None.

2012
Specialty Crop Block Grant Program – Farm Bill (SCBGP-FB)
FINAL REPORT ATTACHMENTS

USDA, AMS Agreement No:
Specialty Crop Agreement No. 12-25-B-1448

State of California
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Date Submitted:
December 24, 2015

California Department of Food and Agriculture
2012 Specialty Crop Block Grant Program –Farm Bill
CFDA # 10.170
Final Report Attachments

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SPECIALTY CROP BLOCK GRANT PROJECTS

Attachment A: California Food System Alliance Network

SCBG Project Documentation ⬩ Ag Innovations Network 2012-15

Producer Advisory Council
of the California Food System Alliance Network
Ag Innovations Network

Thank you for considering joining the Producer Advisory Council!

The Producer Advisory Council (PAC) was been created in October 2013 to help Ag Innovations Network ensure that our Food System Alliances understand and recognize the needs of specialty crop producers in California.

Participants in the Council provide much needed input on grower priorities and that can be addressed by our local Alliances. It is also an opportunity to discuss issues of concern and solutions with growers, organizations and food system efforts around the state.

The PAC is comprised of one agricultural/producer rep from each of the Food System Alliances. We meet quarterly by phone for 60 minutes and calls will be scheduled at the most convenient times for all. We estimate the total time commitment to be part of the Council is less than 6 hours a year including your time to review meeting notes.

Members are asked for their input on:

1. What specialty crop grower needs are at the county level, focusing on local challenges;
2. Issues and actions that localities can collaborate on for greater impact;
3. How our programs might evolve to assure effectiveness, now and in the future;
4. Communicating the priorities and challenges of specialty crop growers to food system stakeholders and communities throughout California; and
5. Ensuring a strong, consistent grower perspective in state and regional initiatives.

The Council will be facilitated by Timothy Griffin, Senior Facilitator and Alliance Program Manager.

Our goal is to make these short calls informative for participants as well as an important source of information and direction for our work.

The PAC is comprised of producers representing each Alliance.

- Robert Abbott, Santa Barbara
- Carol Chandler, Fresno
- Helen McGrath, Ventura
- Scott Murray, San Diego
- Kelly Nelson, San Mateo
- Jennifer Scheer, Santa Clara
- Paul Vossen, Sonoma

Please contact Lisa with any questions:
Lisa Badenfort
Ag Innovations Network
707-823-6111
lisa@aginnovations.org

PRODUCER ENGAGEMENT

California Food System Alliance Network • Producer Advisory Council
Ag Innovations • Spring 2015

PROJECT BACKGROUND

The Producer Advisory Council (PAC) was created in October 2013 to ensure a strong, consistent specialty crop grower perspective in our state and regional food system initiatives. Comprised of producers and representatives from across the Alliance Network, the PAC provided integral guidance to our state and local-level food system programs.

Producer Advisory Council Members

- Carol Chandler, Fresno Food System Alliance
- Helen McGrath, Ventura Ag Futures Alliance
- Kellyx Nelson, San Mateo Food System Alliance
- Gillian Fitch, Sonoma County Food System Alliance
- Robert Abbott, Santa Barbara Ag Futures Alliance
- Scott Murray, San Diego Food System Alliance

Project Contributors

- Kristi Lyn Levings, Yolo Ag & Food Alliance
- Heather Granahan, Sonoma County Food System Alliance
- Evan Wiig, Sonoma County Food System Alliance

Producer Engagement Project

We have observed a growing trend; food system coalition members regularly highlighting ongoing difficulties leveraging and/or retaining the agricultural producer voice in their work, particularly in more urban-focused groups. Why?

Why is inclusion of specialty crop producers crucial to food system planning and action?
As food system planning and action grows increasingly sophisticated, retaining a systems-level perspective is of ever-greater importance to food system improvement. Specialty crop production is a key component of California's food system; in addition to growing our nation's food, producers play a primary role in ecosystem services, natural resources stewardship, and California agriculture's overall success. Missing this input can lead to costly hurdles, including underutilized or insufficient services, missed opportunities across sectors, and an estrangement between farmers and communities. As we move toward greater collaboration, the voice of producers is increasingly essential to the viability of our food system.

ENCOURAGING PRODUCER ENGAGEMENT

The Producer Advisory Council and Alliance Network leaders offer the following suggestions for encouraging/increasing producer engagement in food system coalitions:

Meeting Structure

Rethink traditional methods of engagement: Many coalitions hold monthly meetings, year-round, during regular business hours. This schedule is extremely difficult for producers to accommodate as farming entails a much different work structure – but this is not impossible to navigate.

- **Alternative structures and scheduling:** Be strategic about getting farmers' perspective
  - Hold 1-3 meetings during the off-season specifically intended to leverage producer input; hold summit-like meetings that address a wide range of issues (rather than individual topics)
  - If monthly meetings are unavoidable, **meeting in the early evening** may enable attendance
  - Recognize the seasonality of farming by **creating alternative membership structures**
    - Allow different/rotating farmers to fill permanent producer "seats" on coalitions
    - Diversify attendance requirements and find creative, alternate forms of participation

   - **Location**: **Meet on-farm whenever possible.** Farms are often located outside of the urban centers of town (where coalition meetings are regularly held), requiring increased travel time
   - **Technology**: Many organizations are using online communication platforms - some farms do not have high-speed internet access, and online media is not always a workable solution
- **Participation**:
   - Coalitions are oftentimes heavily represented by nonprofit organizations and other public sector groups, rather than farmers and processors – this can be disconcerting to producers as they have distinct issues and meetings can appear ill-suited to their economic interests.
   - Associations and representative groups include a tremendous diversity of farmers – be mindful of this diversity when considering whether or not “agriculture” is at the table
   - Build in methods of accountability and consistency to support thriving relationships

Meeting Content

- **Agendize opportunities for:**
   - Dialogue about directly-related issues where producers’ perspective will make a difference
   - Action-oriented decision-making and planning that benefits producers
   - Addressing multiple food system issues (rather than separate meetings on individual issues)
   - Networking and learning with other farmers, regulators, and interests/partners
   - Horizontal exchange, where farmers can share and collaborate freely, promote businesses, and share resources
   - Multi-generational knowledge sharing with beginning farmers
- **Diversify the “asks”**
   - Ask producers to provide input on their specific needs (avoids assumptions and misunderstandings that can cloud the planning and implementation process)
   - Ask producers to suggest programs, trainings, services
   - Ask producers broader questions about food system change and long-range visioning
- **Food and beverages**: Serve high-quality, locally-grown and/or processed food and beverages; highlight the source/donor whenever possible
- **Atmosphere**: Encourage an enthusiastic, energizing, positive atmosphere (before and after)

Topics of Interest

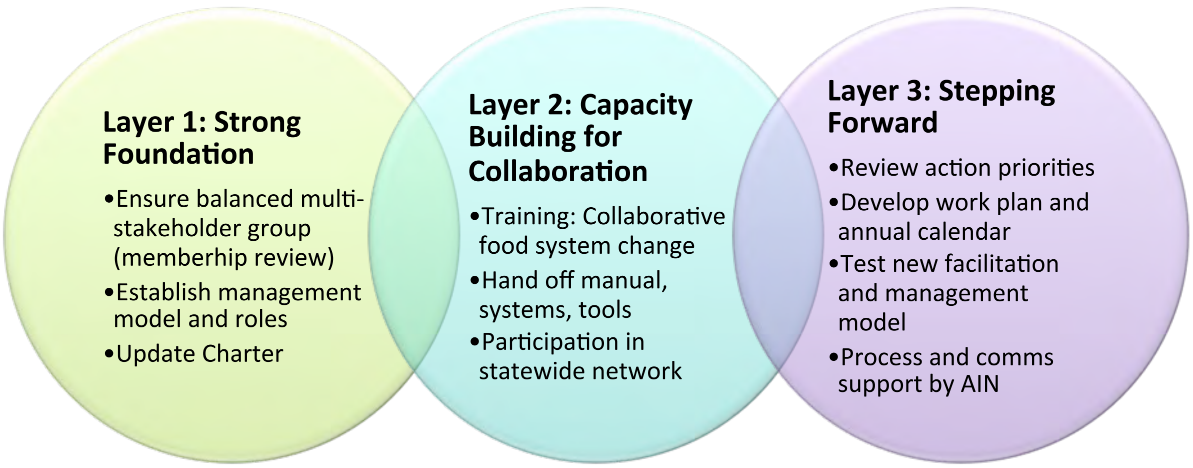
- Teaching farmers to be better – skill development, new technologies
- Water resources, water quality
- Crop diversity, and new crop viability
- Workforce shortages, benefits, challenges
- Long-range planning
- Business development

Alliance Transition: Capacity-Building

California Food System Alliance Network
Ag Innovations Network • 2014 - 2015

In collaboration with Alliance members, Ag Innovations Network is preparing each group to become self-sustaining entities with effective self-facilitation and independent, local management. One of our main focus areas at the program level is on packaging and sharing the tools, training and resources needed for a successful transition – everything we have learned about effective collaboration in the context of food system change.

With this in mind, AIN has designed a robust transition plan to support Alliances implementing a new self-management structure. As groups transition, AIN's strengthened network support functions will be packaged and offered, while at the same time, we will continue providing ongoing, high-impact support.



Each transitioning Alliance will be offered the following services:

- Ongoing, remote process coaching and facilitation support by AIN, including action planning, priority-setting, process design, facilitation, logistics, communications
- A resource bank of facilitation, project management, and organizational management tools and templates for Alliance use
- Web platform support, databand online collaboration tools
- Documentation/file transfer to online platform
- Ongoing training opportunities; and a vibrant learning community where members from across the state can share and learn from each other, including:
    - Collaborative Leadership Training
    - Salon Series (8-part webinar series)
    - Resources and publications sharing across the network

SERVICES DETAILS

Ongoing FSA Support: Ongoing service to the network of Alliances will continue (agendas, notes/results, project support, communications), and transition support will be offered by a full team of AIN staff.

Alliance Toolkit/Manual: AIN has launched a toolkit of more than 30 key tools, templates, and guides for Alliances to address many subjects integral to the seamless management of a multi-stakeholder collaborative initiative. Topic areas include: Action & Committees, Monthly Alliance Meetings, Program Planning, Communications, Process Guides for Alliance Activity, Membership & Recruitment, and a range of additional tools. This toolkit is available online to Alliance members and represents AIN's industry knowledge from more than 14 years of managing agriculture-community collaborations in California.

- Login/access information: http://aginnovations.org/alliances/toolkit/
- Username: toolkit; Password: ag2014

Salon Series: AIN produced an 8-part webinar series designed to help groups transition to self-management as well-coordinated, effective agents capable of making change in specialty crop industry and California food system. This series aims to connect members across the state to share knowledge and best practices for food system improvement with topics primarily focused on the "hows" of collaborative change. Each salon will be accessible here – posts will include webinar videos, presentations and related supplemental materials.

Collaborative Leadership Training: The CLT is designed to increase the capacity of members to serve as leaders and change makers in the context of collaboratives working on issues that address the needs of specialty crop growers. The skill building session focused on supporting food system leaders to develop the core leadership and collaboration skills they need to improve their ability to work effectively together and in their communities.

Alliance Preparation/Training: AIN will provide the following trainings and skill development activities:

- Priority-Setting and action planning
- Facilitation and meeting design
- Communications (media, outreach/networking, messaging)
- Meeting Logistics: Agenda development, notes/minutes

Charter/Constitutions will be updated and provided to groups

Website & File Transfer: AIN will identify and coordinate with lead members from each FSA to ensure they are fully prepared to operate independent websites and access all program documentation. All archived meeting, membership, and project materials will be made available via straightforward online platforms, and will remain hosted until at least December 2015.

- **Website Transfer:** We are preparing Alliances to manage their own websites and want to ensure groups have ample time to convert to new platforms. AIN will continue to reference Alliances on our site and look forward to including links to your new online home. AIN will offer setup for independent websites and required accounts. Logos, charters, membership and contact information will be inserted - and all news article content will be made available on each groups' new online file system. In preparation, AIN will streamline landing page content, update news and action items, and provide all text and image files.
- **File Transfer**: We have setup a new online/shared account for all Alliances to use, and have transferred all program, project and membership files. From there, Alliances can select and download any content for your records and future websites.

Templates/Forms: Alliances will be provided templates for meeting notes, agendas, rosters - other templates will be uploaded to their online file system. Logos will also be provided.

Resources & Publications: AIN will make available to all Alliances the publications and major resources produced throughout the network. Alliances have built Food Action Plans, food system assessments, and reported on significant issues and events that have been utilized as models throughout the network.

CONTRA COSTA FOOD SYSTEM ALLIANCE

Report: Piloting New Alliance Launch Protocol
California Food System Alliance Network
Ag Innovations Network 2014-15

In January 2014, Ag Innovations Network (AIN) formally launched and commenced regular monthly meetings for a new Food System Alliance in Contra Costa County (CCFSA).

Membership/Stakeholder Recruitment
Three convening members - Kathryn Lyddan (Brentwood Agland Trust), Mark Westwind (Sustainable Contra Costa) and Tanya Rovira (CC Health Services) - in partnership with AIN, helped to build an invitation to citizens to join the CCFSA. Potential members from the food/farming sector were identified by their service in the sector and in relation their stakeholder representation. Founding members sought well distributed representation from the following stakeholder groups: Access/Food Security, Ag Support, Community/Civic, Conservation, Education, Fisheries, Food Service, Grocery Outlets, Health, Processors & Distributors, Production Agriculture, Urban Food, Food System Workforce. The Alliance now includes 30 members representing 9 sectors, and has made significant progress since January 2014.

2014 Roadmap *(see page 4 for 10-meeting planning overview and objectives summary)*
In its first year, key areas of focus were two-fold; one dedicated to creating a healthy co-collaborative Alliance able to withstand the test of time, the other the group's work product. To the first, in a very limited timeframe, the Alliance was successful in developing and adopting a charter for its operational foundation, which includes such things as the vision, long-term goals, principles of practice, membership requirements, governance structure, etc., *(see CCFSA Charter)*. The Alliance also developed a full suite of tools to assist with their ongoing fundraising efforts, including a budget, templates and a list of potential funders, and a timeline for approaching each.

To the latter, early in the year, the Alliance identified a Contra Costa Food System Assessment as the focus for their work. The CCFSA has worked diligently toward the completion of this goal, and will continue to do so throughout 2015. The work completed in 2014 includes an outline for the document, problem statements for each chapter as well as the gathering of documents for reference in each. In 2015, the Alliance will invite community experts to help inform specific chapters and hopes to finalize the report by Dec 2015.

Lessons Learned
AIN brings a well-tested, effective process to convening an Alliance. This process worked very well and a successful model was designed and implemented, and a productive, well-functioning Alliance continues to operate in the county.

1. Selecting a process committee (3-5 key players in the county)
2. Process Committee selecting a key group of stakeholders to invite as initial members
3. Hosting an open house for invitees to learn more about the Alliance

Group Development
As a forming exercise, 'fishbowls' were a powerfully effective way to build understanding and camaraderie amongst Alliance members. Many members spoke to all they learned and the new understandings they took away from this process.

The group then began development of its vision, principles of practice and goals. Through the development of these shared aspects of a resilient food system members galvanized their energy and respective talents to finalize their charter, set out strong goals for 2015 (Assessment) and develop materials and a plan for their fundraising efforts.

Priority-Setting
The Alliance immediately felt it needed a more comprehensive assessment of the county food system before it would be able to determine the Big Hairy Audacious Goals it will work on. They decided that a Contra Costa Food System Assessment would be their priority for the near future, working toward completion as early as summer 2015. A formal Assessment Committee was formed to lead the project. The Assessment is meant to paint a robust picture that, among other things, will highlight the gaps and opportunities in the county. From this informed perspective the Alliance can determine its next area/s of action.

Fund Development
The CCFSA Fundraising Committee worked hard toward the accomplishment of their 2014 goals, to raise $10k to continue AIN services and anything extra would be directed toward their 2015 budget. Despite their best efforts, the group was only able to raise $1K. Much of their time was spent developing necessary materials for continued fundraising (template, budget, funders list).

We recognize that the one-year fundraising expectation was to ambitious for a few reasons; a group in its forming stages has difficulty understanding and explaining its value/s, once the Alliance has determined its goals (6 months in) there is a very short window for fundraising by years end, and time in the first year was best utilized with the development of the fundraising materials that the group will need ongoing.

AIN will continue to work with Alliance on a case-by-case basis regarding funding needs. Ideally, we now recognize, funding is best brought to the table beforehand.

Transition Activities
Transition activities for the Alliance include aspects such as meeting management and fiscal sponsorship. The CCFSA was quick to align its members and resources to create an ongoing structure that they anticipate will work best. Mark Westwind, founding member, offered fiscal sponsorship services from Sustainable Contra Costa. Both the Alliance and Sustainable Contra Costa are in favor of this arrangement and details are being set into place.

In preparation for transition over the course of meetings in 2014 the Alliance was also prepared with a review and implementation of the Alliance Toolkit (toolkit - ag2014) which provides members all meeting management and logistics, communications, annual planning and priority-setting, membership recruitment, consensus-based decision-making, managing group dynamics, among other things. The Alliance also attended a Collaborative Leadership Training to help with their continued understanding of working in consensus groups.

The Steering Committee of the Alliance is managing all transition details for the group. Select members of the committee will rotate responsibilities throughout the monthly meeting cycle (i.e., rotation of facilitation and note taking responsibilities). The Committee will continue with agenda development. With their experience in the first year they are well set for success in 2015.

Conclusion

The new Alliance model piloted in Contra Costa County has proven to be a successful model for Alliance development. Bringing together a decade worth of knowledge and experience in local food collaborative development, Ag Innovations Network was able to streamline the process and build local capacity for self-management to sustain such an effort in a consolidated timeframe. Connecting local specialty crop growers to those in the County who can buy and distribute their products, the development of policies that support local agriculture, and the continued development of local/regional systems that support local growers are key factors for the continued participation of local specialty crop growers.

Objectives	Corresponding Activities/Deliverables
Build a cohesive group able to effectively work and act together	Principles of practice, purpose statement, principles of organization, collaboration training
Raise $10-20k 2014 plus if possible additional funds for 2015 operations	Fundraising effort, 2015 budget
Deepen understanding of food system opportunities and gaps in CC	Assessment Exercise
Identify priority areas of action	List of Work Priorities, Action Plans for each priority
Develop systems and structure to effective sustain Alliance operations	Alliance Charter, Work Committees, Self-management framework

Internal Focus: Creating a Strong Container

Week	Meeting 1	Meeting 2	Meeting 3	Meeting 4
Meeting Objectives	• Ensure member clarity about how an FSA works; • Establish Ground Rules (foundation for principles of organization)	• Increase member understanding of the perspectives and values of different stakeholder groups	• Increase member understanding of the perspectives and values of different stakeholder groups; • Effectively prep members for execution of data collection project	• Align on vision for what a vibrant, durable, and equitable food system looks like in Contra Costa County • Begin Charter development • Fundraising Committee formed

External Focus: Our Work in the County

Meeting 5	Meeting 6	Meeting 7	Meeting 8	Meeting 9	Meeting 10
• Expand members understanding of current state of Contra Costa County Food System • Identify Alliance priority Areas	• Collaborative Leadership Training	• Determine structure and timeline for Alliance Priority Area (CCC Food System Assessment) • Continue work in Priority Area • Continue Fundraising efforts • Continue work on charter	• Align on structure to support Alliance after transition • Fiscal sponsor determined • Identify admin & facilitation • Continue work in Priority Area • Continue Fundraising efforts • Continue work on charter	• Review, refine, and approve management model Continue work in Priority Area Continue fundraising efforts • Continue work on charter	• Adopt Charter • Continue work in Priority Area • Planning for q1 meetings

INTERNAL FOCUS: Creating a Strong Container

Week	**Meeting 1**	**Meeting 2**	**Meeting 3**	**Meeting 4**
Meeting Objectives	Ensure member clarity about how an FSA works; Establish Ground Rules (foundation for principles of organization)	Increase member understanding of the perspectives and values of different stakeholder groups	Increase member understanding of the perspectives and values of different stakeholder groups; Effectively prep members for execution of data collection project	*Align on vision for what a vibrant, durable, and equitable looks like in Contra Costa County *Begin Charter development *Fundraising Committee formed
Meeting Activities	*Overview of FSA Process *Ground Rules (initial work on principles) *Review objectives and timeline *Intro to Dialogue	*Stakeholder fish-bowls (2) *Opportunity analysis based on fish-bowls *Funding discussion	*Stakeholder fish-bowls (1) *Opportunity analysis based on fish-bowls *Stakeholder Mapping Exercise *Prep members for data collection project	*Determine Alliance capacity (e.g. how many committee, efforts can be managed p/ yr)
Pre-Meeting Assignment & Activities	N/A	Prep member participants for fish bowls	Prep member participants for fish bowls	(1) Launch of data research project;
Notes/ Comments	Ground rules become basis for principles of organization (will continue to be added to each meeting		Discussed that these fishbowls don't need to manage "conflict" in the same way some fish bowls do, so the focus here will be both helping the group learn more about these stakeholder groups as well as share how they believe their "cause" would benefit from the work of a multi-stakeholder collaborative like the Alliance. This becomes the launching pad for the assessment work in meeting 6	

EXTERNAL FOCUS: Our work in the County					
Meeting 5	**Meeting 6**	**Meeting 7**	**Meeting 8**	**Meeting 9**	**Meeting 10**
*Expand members understanding of current state of Contra Costa County Food System *Identify FSA priority areas	Collaborative Leadership Training	*Determine structure and timeline for Alliance Priority Area (CCC Food System Assessment)	*Align on structure to support Alliance after transition *Fiscal sponsor determined *Identify admin & facilitation	*Review, refine, and approve management model *Continue work in Priority Area	*Adopt Charter *Continue work in Priority Area *Planning for q1 meetings
*Review key county data *Identify key trends, threats, opportunities *Introduce & Develop Principles of Practice list *Revisit ground rules and additional adds that are moving towards the principles of practice *Finalize priority areas, including commissions committees for work			*Determine skeleton framework for sustaining Alliance after transition	*Finalize management model (as needed approve any members taking on roles) *Share Alliance toolkit *Develop protocol for web and database updates, clarifying legal structure (e.g., fiscal sponsorship with AIN)	*Review January agenda *Final review and adoption of charter *Review AIN Network tools and resources *Discuss how AIN can be supportive in 2014
	Final prep for presentations; Finalizes principles of practice and principle of organization (2) Members ask to reflect and bring in a list of their beliefs about food system as fodder for discussion on Principles of Practice	Members reflect on previous meeting and bring 3-4 possible priorities to the next meeting	Finalizing management model	Sub group finalizes management structure to propose to group	Sub-group works on developing draft charter

	This is a chance for the group to get more informed about what is going on in the county. I see this as both talking about key ag. Consumption, env data, but also to discuss other realities, like politics, culture, and economic. Might be good to have some expert guests attend? Thinking maybe folks that could come reflect on what they are seeing happening in the county and how they envision and Alliance like this being most effective is supporting the county	With systems thinking, food systems overview, and the county specific data analysis behind them,	Group would be tasks to develop potential mode and bring the proposal to group to review?	Building on the priority issues discussed in the previous meeting, the alliance will begin to determine how it will work on those issues, and	

OPPORTUNITY SUMMARY

As part of a Specialty Crop Block Grant, Ag Innovations Network (AIN) is funded to partner with food system collaboratives, policy councils, or project-based community coalitions with the intended goal of increasing their effectiveness and impact. As part of the engagement, AIN will: (1) conduct an initial assessment to identify and prioritize opportunities and gaps, and (2) co-design and execute a short-term engagement with each participating coalition to capitalize on opportunities and address gaps. To be eligible, candidate groups' goals or project(s) must include increasing the viability of California specialty crop industry/growers, increasing the sale and consumption of California-grown fruits, vegetable, and nuts.

BACKGROUND

Over the last 10 years, Ag Innovations Network has actively worked to develop local and statewide coalitions capable of supporting their communities in developing more vibrant, durable, equitable, and sustainable food systems, most notably as conveners of California Food System Alliance Program. During this time, AIN found that effective Alliances, Food Policy Councils and other food collaboratives have contributed towards the increased viability of California specialty crop producers, and to that end, have been funded as part of a Specialty Crop Block Grant to elevate the capacity of existing groups and improve service and support to specialty crop growers.

PROJECT DETAILS

AIN will partner with community food coalitions/councils who are interested in (or currently working on) developing policies and projects that directly or indirectly benefit California's specialty crop growers (e.g., farm-to-school, food access, local procurement, aggregation and distribution.)

Services offered include (1) increasing group's ability to effectively collaborate, (2) supporting with the identification of actions/policy priorities, and/or (3) supporting with the execution of efforts already underway. These services will be covered by our Specialty Crop Block Grant and as such will be free of charge. In some cases, groups may be asked to contribute towards covering AIN's travel costs.

OFFERING	SAMPLE PROCESS
3 models of short-term/multiple-month engagement; working with existing groups to *identify places where consulting services could benefit them on: 1. **Internal capacity** (creating conditions for groups to work better together) 2. **Strategic planning** (what to work on and how to work on it) 3. **Support existing projects** (increasing impact, speed, effectiveness) * Following a needs assessment	1. Initial outreach/connection 2. Setup call/meeting 3. Needs Assessment 4. Services/offerings considered 5. Contracting/agreements 6. Engagement 7. Evaluation

GROUPS ELIGIBLE FOR PARTNERSHIP

- Diverse, multi-stakeholder groups with an interest in advancing the viability of specialty crop growers
- Groups with projects already in place that directly benefit specialty crop growers
- Groups working in communities with a strong agricultural (specialty crops) presence
- Groups that are already positioned to make change
- Groups seeking ongoing collaboration with their community (rather than ad-hoc or single-purpose projects)
- New/emerging groups

GROUP ASSESSMENT

Capacity-Building Program (v2)

Ag Innovations Network • Fall 2014 - Summer 2015

PAGE 1: THE MOST IMPORTANT QUESTIONS FIRST

Before we get into a busy survey, we want you to answer to simple questions. Here they are…

1. Reflecting on the question, "How could my experience of participating in the group be more meaningful?" What is the single most important thing that you'd like us to know?

2. If you could change one thing about how the group functions, what would it be?

PAGE 2: MEMBER BACKGROUND

3. Name & Organization/Affiliation (optional):

4. Primary Stakeholder Group: Please select the stakeholder group you most closely identify with. You will have the opportunity to identify additional sectors/affiliations. (only one answer)

- Agricultural Production (farming, ranching, floriculture, viticulture, forestry)
- Ag Support (licensing/permitting, technical training, advocacy)
- Civic/Community (related nonprofits, public employees, fraternal organizations)
- Conservation (preservation, open space/land preservation, stewardship)
- Education (K-14, higher education, training/technical assistance)
- Fisheries (catching, raising, processing)
- Food Service (prep, sale, and/or delivery; restaurants, public food service)
- Grocery Outlets (retail; sale/distribution of food, farmers markets, grocery stores)
- Health (medical professionals, public health, service providers, for/nonprofit staff)
- Processing & Distribution (aggregating for distribution, hubs, businesses, raw/value added)
- Urban Food (community gardens/kitchens, sourcing from urban areas)
- Workforce/Labor (food system workers, farmworkers, labor advocates)
- Multiple choice (only one answer)

5. Secondary Stakeholder Group: Please select as many secondary groups that you're affiliated with. (select as many as needed)

- Agricultural Production (farming, ranching, floriculture, viticulture, forestry)
- Ag Support (licensing/permitting, technical training, advocacy)
- Civic/Community (related nonprofits, public employees, fraternal organizations)
- Conservation (preservation, open space/land preservation, stewardship)
- Education (K-14, higher education, training/technical assistance)
- Fisheries (catching, raising, processing)
- Food Service (prep, sale, and/or delivery; restaurants, public food service)
- Grocery Outlets (retail; sale/distribution of food, farmers markets, grocery stores)
- Health (medical professionals, public health, service providers, for/nonprofit staff)
- Processing & Distribution (aggregating for distribution, hubs, businesses, raw/value added)
- Urban Food (community gardens/kitchens, sourcing from urban areas)
- Workforce/Labor (food system workers, farmworkers, labor advocates)
- Multiple choice (multiple answers)

6. How long have you been involved with the FPC? (only one answer)

- 0 - 6 months
- 6 months - 1 year
- 1 - 2 years
- 2 - 3 years
- 3+ years

7. Why do you participate in the FPC? Please rank the following in order of importance, starting with the most important to the least. (forced ranking, 1-6, n/a column available)

1. Learn more about the food system
2. Network with peers
3. Stay abreast of food system related activities in the county
4. Improve our local food system
5. Leadership development
6. My job requires my participation

8. Frequency of meeting attendance (only one answer)

- Attend all
- Attend most
- Attend some
- Attend few
- Attend very few

9. How many hours a MONTH - not including the monthly meeting - do you spend on FPC related activities? (only one answer)

- 0 - 30 minutes
- 30 minutes - 1 hour
- 1.5 - 2 hours
- 2.5 - 3 hours
- 3+ hours

10. What level of support do you receive from your organization to participate in the group? (only one answer)

- Very supportive - they see it as a part of my job
- Somewhat supportive - they are glad I participate, but it's not officially part of my job
- Indifferent
- Not supportive - they don't think it's a good use of my time
- N/A - I am not representing an organization

11. What is your understanding of the primary purpose of the FPC?

12. What issues are most important to you personally? (please select NO MORE than 3)

- Ag viability
- Distribution, aggregation
- Economic development, localization
- Environmental stewardship, natural resources
- Farm to institution (schools, hospitals, etc.)
- Food access, justice, resilience
- Labor, workforce
- Processing, manufacturing
- Public policy (food system)
- Regulatory environment (permitting, licensing)
- Regional food system development
- Water resources/quality

13. What are the top 3 priorities/actions you would like to see the group focus on in 2015-16?

- Priority 1:
- Priority 2:
- Priority 3:

14. Is there anything else in regards to the "WHY" you participate and "WHAT" you want out of your experience you want to share?

PAGE 3: EVALUATION

In this section, we will ask you to evaluate how effective the group, using the following 7 areas as a guide:

1. "**SHARED PURPOSE & VISION**" – How clear the group's purpose is and how closely the work of the group aligns with the purpose and vision
2. "**GROUP ENGINE**" – The basic structures that allow a council to function effectively – admin, logistics, facilitation
3. "**QUALITY OF EXPERIENCE**" – How members feel about being part of the group
4. "**COMMITMENT & ACCOUNTABILITY**" – How committed the group is to the execution of its vision and purpose
5. "**GENERATIVE CONVERSATION**" – How capable the group is at engaging in deep dialogue and creative thinking that results in the development of effective strategies and resolving conflict
6. "**IMPACT**" – Explore the impact the group is having in the community
7. "**CONTINUOUS IMPROVEMENT**" – How competent the group is at adapting to the changing needs of their members and the community

15. SHARED PURPOSE & VISION: How clear the group's purpose is and how closely the work of the group aligns with the purpose and vision (1-5 rating scale, strongly disagree to strongly agree, comment box)

- We are clear on what we are trying to accomplish together
- We have a set of shared values - either formal or informal - that we respect in our work together
- How we spend our time is consistent with what we think is most important

16. Is there anything else related to "SHARED PURPOSE & VISION" that feels important to share? Rating scale (1-5 rating scale, strongly disagree to strongly agree, comment box)

17. GROUP ENGINE: The basic structures that allow a council to function effectively – admin, logistics, facilitation, etc.

- We have an effective process for managing basic meeting logistics (e.g., scheduling, note-taking, facilitation)
- We have a clear decision-making process in place
- It is clear when a decision is made and what the decision was
- We have effective systems in place to ensure we minimize the amount of time spent rehashing old business or decisions
- We have effective structures for managing work
- We are effective at prioritizing
- We know what is expected of us as members
- We have effective processes in place to ensure we have the right people in the room
- We have a clear and effective way to communicate important information to our MEMBERS
- We have a clear and effective way to communicate important information to the PUBLIC
- We have an effective process to identify and secure resources we need (e.g., funding)

18. Is there anything else related to "GROUP ENGINE" that feels important to share?

19. QUALITY OF EXPERIENCE: How members feel about being part of the group (1-5 rating scale, strongly disagree to strongly agree, comment box)

- I enjoy participating in the group
- I feel like my voice is heard
- I feel safe in the group
- Serving on the group is a good use of my time
- I enjoy our meetings

20. Is there anything else related to "QUALITY OF EXPERIENCE" that feels important to share?

21. COMMITMENT & ACCOUNTABILITY: The group's commitment to the execution of its vision and purpose (1-5 rating scale, strongly disagree to strongly agree, comment box)

- Members meet their commitments
- The workload is well balanced (or, if there is an imbalance, it is done so consciously and intentionally)
- We do what we say we are going to do

22. Is there anything else related to "COMMITMENT & ACCOUNTABILITY" that feels important to share?

23. GENERATIVE CONVERSATION: How capable the group is at engaging in deep dialogue and creative thinking that results in the development of effective strategies and resolving conflict (1-5 rating scale, strongly disagree to strongly agree, comment box)

- The group encourages members to voice disagreement
- Generally, members voice their disagreement or concerns when they have them
- I voice my disagreement and concerns

- When disagreement/concerns are raised, our group handles them effectively
- Group members, as a whole, are able to suspend their own judgment and consider other points of view
- Our group discussions push us to think
- Our conversations often result in the group having a new understanding about the topic at hand

24. Is there anything else related to the "GENERATIVE CONVERSATION" that feels important to share?

25. IMPACT: The impact the group is having in the community (1-5 rating scale, strongly disagree to strongly agree, comment box)

- Our work is yielding results in the community
- The amount of effort we put in is proportional to the results we achieve
- Our work is unique and non-duplicative
- What we work on feels appropriate given who we are

26. Share up to 3 examples of outcomes of your work that have made and impact and how

- Example 1:
- Example 2:
- Example 3:

27. Share an example of something you worked on together that was NOT worth the time invested and why

- Example 1:
- Example 2:
- Example 3:

28. Is there anything else related to "IMPACT" that feels important to share?

29. CONTINUOUS IMPROVEMENT: The competency of the group at adapting to the changing needs of its members and the community (1-5 rating scale, strongly disagree to strongly agree, comment box)

- We stay current on food system trends
- We are current on relevant food system related activities in the county
- We regularly reflect on our work together to ensure we are on track
- We invest the right amount of time thinking about our community's future needs

30. Is there anything else related to "CONTINUOUS IMPROVEMENT" that feels important to share?

31. Is there anything else related to this EVALUATION SECTION that feels important to share?

PAGE 3: THE MOST IMPORTANT QUESTIONS LAST

1. Reflecting on the question, "How could my experience of participating in the FPC be more meaningful?" What is the single most important thing that you'd like us to know?

2. If you could change one thing about how the group functions, what would it be?

COLLABORATIVE LEADERSHIP TRAINING

California Food System Alliance Network • Outline Development
Ag Innovations 2014

BACKGROUND ON THE TRAININGS

The training series is designed to increase the capacity of Alliance members to serve as leaders and change makers in the context of collaborative approaches to food system change. Alliance members are by and large strong leaders in their communities but their individual actions can be siloed and in some cases duplicative or at cross-purposes. In order to support further leadership development in these communities and enhance the effectiveness and coordination of their action, we will offer capacity-building training to existing and newly forming Alliances. Trainings will focus on individual and group leadership, facilitation and process skills, effective collaboration, food system literacy, and collective impact. We will seek to provide each Alliance with the tools, resources, and support it needs to become a locally self-sustaining entity.

AUDIENCE

The audience for the trainings is Food System Alliance members. Assumptions about the audience:

- Have good understanding of one aspect of the food system and are passionate about it
- Have limited knowledge of the whole food system
- Have worked in collaboration with others but don't tend to have framework or strong skills in the area
- Many are "doers" with a preference for action over reflection
- Most have higher education and have taken trainings in the past

LEARNING OBJECTIVES

1. Participants will understand the principles of effective collaboration and gain skills to be strong leaders in collaborative settings; including communication, dialogue, and leadership skills.
2. Participants will be able to articulate a theory of change for collaborative change in the food system and the collective impact framework.

DESIGN

- Process approach:
- Timeframe: 3 hours
- Materials needed: Handouts (5), presentation, supplies for group work and breakouts
- Follow-up reinforcement: how do participants carry their learning forward?

TOPICS TO CONSIDER

- Being an effective participant in a multi-stakeholder collaboration
    - What is an effective collaboration
    - Collective impact
    - Dialogue
    - Communication skills; deep listening
    - Group dynamics, group process
    - How to "show up"; Leadership/follow-ship—shared leadership in collaborations
    - Self-reflection; seeing oneself as subjective rather than objective
    - Power and influence in groups
- Intro to facilitation—role of participants in supporting effective facilitation
- Intro to consensus process
- Collaborative approaches to problem-solving
- Intro to Theory U principles
- Bradford effective influence

OUTLINE & OBJECTIVES

Collaborative Leadership Training

Ag Innovations 2014

SECTION 1: INTRODUCTION

- Clarify the difference between a participant and facilitator

SECTION 2: DEFINING THE FIELD

- To bring forth the knowledge of the group on the topic of effective participation essentially defining the scope of the workshop
- To practice concise storytelling, active listening, aggregation of group knowledge and division of tasks

SECTION 3: YOURSELF

- To lead participants to understand that emotional states affect our thinking and effectiveness as group participants
- To introduce participants to a practical tool for selfocalming during group work
- To lead participants to see the importance of self-monitoring
- To practice selfomonitoring, concise speech, personal revelation, deep listening, distillation of themes or core concepts and time keeping
- To give participants concrete actions to take in relation to the data they collect while self-monitoring

SECTION 4: SOURCING AND USING YOUR POWER

- To give participants some insight into the different sources of their power and how they effect power dynamics in groups
- To give participants concrete actions to take in relation to the data they collect while evaluating their own sources of power
- To as participants provocative questions that get them thinking about their relationship with their own power or lack thereof

SECTION 5: RELATIONSHIP; SENSITIVITY TO AND COMMUNICATION WITH OTHERS

- To give people a heightened sensitivity to multicultural issues in their group work
- To make concrete suggestions of places to be especially sensitive
- To give participants insight into the basics of cooperation and collaborative communication

SECTION 6: FRAMEWORKS FOR HEALTHY COLLABORATIVE GROUPS

- To introduce participants to a few frameworks for organizational evolution and the stages of group processes
- Help participants see that difficult times of dissolution and struggle are part of a healthy normal group process
- To lead participants to understand that there are different roles in group systems and they are all input and valuable if they are well-balanced

2014 SALON SERIES

In 2014, Ag Innovations Network offered a series of capacity-building salons to Alliance members and food system groups across the state. During these bi-monthly learning webinars, food system leaders connected with hundreds of stakeholders, learned new tools and shared best practices for collaborative change. Topics primarily focused on the "how-tos" of collaborative change, with each salon featuring an expert presenter on the topic at hand.

JANUARY	**Priority-Setting & Action Planning** • Presenter: Timothy Griffin, Ag Innovations Network • Presentation (PDF)
FEBRUARY	**Sonoma County Healthy & Sustainable Food Action Plan** • Presenters: Sonoma County Food System Alliance (members, team) o Phina Borgeson, Tanya Narath, Jana Hill, Lisa Badenfort • Presentation (PDF) • Video (mp4) • Recording (audio)
MARCH	**California Drought Special** • Presenter: Sandra Schubert, California Department of Food & Agriculture (fmr) • Presentation (PDF) • Resources & Links • Video (mov) • Recording (audio)
MAY	**Building a Resourceful Alliance (Toolkit Review)** • Presenter: Katie Pease, Ag Innovations Network • Recording (audio)
JULY	**Food "System Thinking": What System Theory can tells us about how to change our food system** • Presenter: Katy Mamen • Presentation (PDF) • Resource Guide (PDF) • Video (mp4)
SEPTEMBER	**Using Teams Effectively: Strategies for leveraging committees to do more** • Presenter: Timothy Griffin, Ag Innovations Network • Presentation (PDF) • Video (mp4)
NOVEMBER	**Finding Higher Ground: How local food collaboratives can become innovation engines** • Presenter: Joseph McIntyre, Ag Innovations Network • Presentation (PDF) • Video (mp4)

The July, September and November salons were produced in partnership with the CA Food Policy Council (a project of Roots of Change).

Pilot: Coordinated Action Proposal for Alliances' Consideration

April 2014

COORDINATED ACTIONS

Alliance members around the state have expressed interest in sharing and hearing about successful actions in other parts of the state in order to take advantage of good work and thinking done in other counties and not have to reinvent the wheel. We are piloting an approach for this that we hope will result in a template and protocol for Alliances to share with each other in the future.

BACKGROUND

Over the past two years, Ag Innovations Network has managed a statewide project addressing regulatory issues as they relate to agriculture. The project was launched in response to requests from agricultural, conservation, and regulatory partners at both state and local levels, and aims to seek solutions that reduce the business challenges associated with regulatory compliance for farmers while also meeting the underlying public goals of regulation.

Alliance members throughout the state have contributed valuable insight and perspectives to the project by hosting listening sessions, participating in focus groups, sitting on the project's technical advisory committee, and attending the culminating *Summit on Regulations Affecting Agriculture* in June 2013.

A final project report comprises the results of the many conversations held throughout the project, and represents the best collective thinking on the topic among stakeholders. The report, *Regulating for Agricultural and Public Outcomes: Perspectives and Recommendations*, includes recommendations for both short- and long-term improvements to our regulatory system, and was officially released in January 2014.

ACTION PROPOSAL

We've identified several recommendations with the potential for county-level impact (enclosed), and would like to present you with the opportunity to engage on moving one or more of them forward in your own county. We've created a template letter (attached) for you to adapt as needed in order to reach out to your local decision makers and request their involvement in moving your selected recommendations forward. Participants in the regulatory project have identified these recommendations as high-leverage opportunity to improve the regulatory process, leading to an easier approach for agricultural producers and regulators alike, and reduced barriers to on-farm restoration efforts among other benefits.

PROPOSED STEPS

- Bring action forward for Alliance consideration
- If consensus to take action:
  - Identify appropriate county-level target audience for the letter
  - Determine if any edits (additions or deletions) need to be made to the letter
  - Empower an Alliance member or committee to revise the letter accordingly and send it off
  - Evaluate pilot

TIMELINE

We recommend considering the action early in 2014 and taking action (as applicable) as soon as possible thereafter.

Attachment B: California Food System Alliance Network
Projects, Events & Accomplishments Supporting Specialty Crop Agriculture
(Oct 2012 - Oct 2013)

I. OMBUDSMAN POSITIONS

2012 Yolo and Solano County Farmbudsman

The YAFA advocated and gained approval for the creation of a bi-county "Farmbudsman" position for Yolo and Solano Counties to support farmers in navigating regulatory and permitting processes in both counties (one of the biggest challenges facing the economic viability of growers in the area) while maintaining environmental outcomes. These recommendations were submitted to the County Administrator's Office (CAO), and half of the funding for the position has been secured from each county's Economic Development Departments. The Farmbudsman position has been filled, which is a huge win for the Alliance and its Solano County partners. Farmbudsman Michelle Stephens now sits on the YAFA and the group has made it a priority to support her in her new role.
http://aginnovations.org/articles/view/yolo_solano_farmbudsman_article_highlighting_michelle_stephens_hire/

- ### Replication of Farmbudsman Recommendation

2013 San Mateo County Ag Ombudsman

The 2012 San Mateo County Ag Workshop, co-sponsored by the San Mateo Food System Alliance (SMFSA) and Supervisor Don Horsley, issued recommendations for an agricultural ombudsman, which were taken up by the county. In early 2013, San Mateo County released an RFP for an agricultural ombudsman position for the County.
http://aginnovations.org/articles/view/rfp_release_for_san_mateo_county_ag_ombudsman/

II. POLICY ACTION & RECOMMENDATIONS

2011 San Mateo County Policy Recommendations

The San Mateo County Food System Alliance's policy brief *Producing, Distributing, and Consuming Healthy Local Food: Ingredients for a Sustainable Food System*, describes six recommended actions to support a sustainable food system in your community/city. Recommendations include updating land use and other local policies to include support for urban agriculture and community gardens, adopting local food procurement policies, supporting local marketing initiatives such as *As Fresh As It Gets*, as well as examples of initiatives in other cities and counties.

Alliance members used the publication as the basis for a series of meetings with city representatives in Burlingame and Redwood City to discuss implementation of sustainable food policies. City officials from both cities were interested in learning more about policies that have been implemented in other cities and requested additional language around specific policies that are recommended for implementation. The Alliance plans to revisit this project by late 2013. http://aginnovations.org/articles/view/smfsa_announces_release_of_food_policy_brief/

- ### Replication of Policy & Recommendations Actions

2013 Santa Barbara Countywide Buffer Ordinance

The Santa Barbara County Ag Futures Alliance (SBAFA) took lessons learned from how Yolo and San Mateo approached policy change, and spent a period of 18 months developing and drafting a buffer policy intended to protect agricultural properties from encroaching uses while also protecting the public from activities normally associated with agricultural production. In April of 2013, after two years of debate, the policy was unanimously adopted as an ordinance by the Santa Barbara County Board of Supervisors, and is to-date the only buffer ordinance in the state. http://aginnovations.org/images/uploads/buffer_zone_presser2.pdf http://aginnovations.org/articles/view/agricultural_buffer_zone_ordinance_approved_in_santa_barbara_county/

III. FARM-TO-SCHOOL PROGRAMS

2011 San Mateo Garden-Based Learning & Farm-to-School Programs

In 2010, the San Mateo FSA published a *Garden-Based Learning Call-to-Action* urging their community to join them in their goal to establish a garden in every school. Garden-based learning (GBL) uses the garden as an outdoor classroom to provide integrated learning experiences, in and across disciplines, through active, engaging real-world experiences that bring abstract concepts to life. Many educators use gardens to enhance learning in core subjects such as science, math and social studies, as well as promote nutrition, environmental stewardship, and create awareness around where our food comes from. 63 percent of public elementary schools in San Mateo County now have gardens. http://aginnovations.org/alliances/sanmateo/action/

In 2011, the San Mateo Food System Alliance (SMFSA) began a Farm-to-School pilot with two school districts, while the San Mateo Farm-to-Institution Committee hosted a seminar for educators, youth and parents who wanted to increase their consumption of locally grown produce.

In 2012, the San Mateo County Food System Alliance organized and hosted it's first annual school garden award ceremony to bring recognition to the schools in the county with the highest garden use and best practices in environmental standards and academic garden-related activities.

Another pilot program, involving outreach to Parent-Teacher Organizations across the county, is now continuing with a fully-developed program involving a short presentation with hand-outs and resources as the Alliance makes an effort to educate parents and teachers at each school about programs like Harvest of the Month, offered by CAFF. This has resulted in the development of new farm-to-school relationships and contracts.
http://aginnovations.org/articles/view/jesse_cool_at_2nd_annual_school_afterschool_garden_ceremony_on_4_27/

➢ Replication of Farm-to-School Programs

2013 Fresno Farm-to-School (F2S) Committee Brokers First-Ever Procurement Contract Between School Districts and Local Growers

The F2S Committee of the Fresno FSA is a partnership of organizations working collaboratively to create a system that increases healthy and nutritious food options for Fresno County children by linking local farms to local schools.

The Committee completed a needs assessment of food service operators. and found that Fresno Unified School District was the only school district, out of 21 in the county, that has the capacity to handle, process, and repackage produce for consumption.

The Alliance has helped facilitate the involvement of technical assistance providers with a goal to create an MOU that outlines a plan for Fresno Unified to begin processing and distribution on behalf of other school districts in the county. The pilot project shows that one purchase order for local farm direct procurement of strawberries by Fresno Unified led to the creation of seven agriculture labor positions and infusion of approximately $100k into the local economy.

F2S Committee has helped create a direct procurement model with 12 districts in Fresno that will begin the implementation phase during the 2013-2014 school year. The first Fresno County Farm to School Forum will be held in October 2013, during the week of Food Day. By Spring 2014, the goal is to add farmers to the equation and begin distribution of local produce to schools on an even larger scale.

Several interviews aired on NPR and Channel 30 Local Ag Watch, highlighting the relationship between strawberry producer and FFSA member, Pao Saephan and FFSA member Jose Alvarado with Fresno Unified School District. These articles highlight their collaborative efforts that are paving the way for other small farmers to sell their produce directly to school districts.

2013 Sonoma Farm-to-School Launch

The FSA helped secure a total of three grants to support a Farm-to-School program in the county (to be led by CAFF), aimed at improving delivery of local, healthy foods to schools. These included a $246,000 community transformation grant for Farm to Cafeteria and aggregation and marketing, a USDA Farm to School grant of approx.. $100,00 and supported a CDFA Specialty Crop Block grant worth $275,000 (which will include Sonoma County but also extend beyond).

To set the foundation, two Food Service Trainings were held in 2011 and 2012, with more than 70 participants, including parents and community members, food service staff, school district staff and producers. Farm-to-School launched in 2013 with localized Harvest of the Month activities and working with food service staff and local farmers to enhance local procurement methods. To help support this work, CAFF recently hired a Farm-to-School coordinator to manage the day-to-day operations of the program for Sonoma County and serve as the liaison to the FSA committee. http://aginnovations.org/articles/view/sonoma_fsa_hosts_school_food_workshop_with_chef_josef_keller_10_25/

IV. FOOD HUBS

2011 Yolo County Food Bank

The Yolo Ag and Food Alliance, in collaboration with the UC Davis Food System Analysis graduate seminar, published the report *Context Matters: Visioning a Food Hub in Yolo and Solano Counties.* This extensive report provides recommendations, and overview of need and infrastructure and will be used as a tool for the YAFA moving forward in its aggregation/food hub efforts.

The Yolo County Food Bank, a member organization of the Alliance, conducted a business plan/feasibility study exploring the potential of expanding the food bank's services to include aggregation, processing, and cold storage services for local producers. The Food Bank recently signed a lease on a new facility with greatly expanded capacity and is preparing to launch a capital campaign in October 2013.
http://aginnovations.org/articles/view/context_matters_visioning_a_food_hub_in_yolo_and_solano_counties/

➢ Replication of Food Hub Efforts

2012 Fresno Food Hub Committee

The FFSA's newly formed Food Hub Committee recently began connecting various projects and initiatives in the county, fostering collaboration, networking, and learning on existing projects and new opportunities for food aggregation, distribution, and processing. http://aginnovations.org/alliances/fresno/news/

V. FOOD SYSTEMS ASSESSMENTS AND PLANS

A. 2011 Sonoma County Community Food System Assessment

One of the first actions of the Sonoma County Food System Alliance was to recognize the need for a comprehensive review of the local food system. The Assessment Committee conducted research and interviews to write and compile a roadmap to a healthier, more profitable and sustainable local food system.

The Sonoma Alliance completed and released the *Community Food System Assessment Report*, and the *Sonoma Food Forum Report* as a follow-up to the Food Forum held in February 2011. Both reports where presented to the County Board of Supervisors and the Alliance will be creating a food policy framework for the County.

http://aginnovations.org/images/uploads/Sonoma_County_Community_Food_System_Assessment.pdf

➢ Replication of Assessment/Reporting Projects

2013 San Mateo County Food System Assessment
The San Mateo Alliance Food System Assessment Committee has nearly finished the draft stages of their assessment, which is due to be published by 2014.

2013 Sonoma County Healthy & Sustainable Food Action Plan
The development of the Sonoma County Healthy and Sustainable Food Action Plan (Action Plan), which was a collaborative effort between the Sonoma County Department of Health Services, the Sonoma County Food System Alliance and community stakeholders provides a county-wide framework to stimulate and coordinate improvements within our food system. The Action Plan encourages local governments, businesses, organizations and individuals to commit to specific actions so they can play a role in building a viable food system for Sonoma County. It was adopted by the County Board of Supervisors, and the SCFSA will take on the development and implementation of the plan in 2013.

As a guiding "north star," the FAP serves as a framework to guide collaborative efforts of diverse stakeholders, catalyze policy change, encourage community support and engagement, and to respect the voices of all industries across the food system spectrum. http://aginnovations.org/images/uploads/SonomaFAP_LR.pdf

2013 Santa Clara County Food System Assessment
The SCCFSA Food System Assessment Committee has compiled existing and primary research on Santa Clara County's food and agriculture system, for both the rural south county and urban north county. The document will be completed in 2013, and will not only be a comprehensive resource for the region to better understand its food system, but will guide advocacy efforts of the Alliance moving forward. It includes 18 concrete recommendations regarding Agriculture & the Economy, Hunger, Food Justice, Health & Nutrition, and Environment, as well as an outline of next steps toward system improvement. http://aginnovations.org/alliances/santaclara/

VI. COMMUNITY AG & FOOD FORUMS

2010 Yolo County Regional Food Forum
The Yolo Ag & Food Alliance hosted a meeting in July 2010 with over 65 agriculture producers, food distributors, institutional food buyers and rural development advocates to address infrastructure needs in the Yolo and Solano county area to help develop a more regionally-focused food system. Many farmers and ranchers in the area have a desire to sell their products more locally, but the lack of basic infrastructure is a major limitation. The meeting identified the critical gaps in agricultural processing, storage and distribution infrastructure and began a process to close some of the identified gaps through a discovery and prioritization process. One of the major needs identified during the meeting was the need for an Ag Ombudsman to assist producers in the navigation of the permitting process and compliance with regulations.

In 2011, the group released a full report on the recommendations made at the Forum, and outlined next steps for attaining the goals outlined therein. By 2012, the position of the Yolo/Solano Farmbudsman was created and funded, and then filled in early 2013.
http://aginnovations.org/images/uploads/Yolo_Food_Forum_Report_Feb._2011_Final_.pdf

➢ Replication of Community Forum Events

2011 Sonoma County Food Forum

Co-hosted by the Sonoma County Board of Supervisors, UC Cooperative Extension, Sonoma County Department of Health Services, and the Sonoma County Food System Alliance, the Sonoma County Food Forum was held on February 24, 2011. Over 300 people participated in the event, which was held at the Santa Rosa Fairgrounds. Speakers and panelists from the local food system included producers and farmers such as Keith Abeles of Quetzal Farm, Doug Beretta of Beretta Dairy, local lamb producer Joe Pozzi, and Sheana Davis of the Epicurean Connection Shop in Sonoma. Local leaders in food security and public health such as Jane Doroff of the Council on Aging, David Goodman of the Redwood Empire Food Bank, and Tom Scott of Oliver's Market, as well as Sonoma County Public Health Officer Mary Maddux-Gonzàlez. Several media outlets covered the Food Forum in February, including Biteclubbeats.com, KCRB, Patch.com, and San Francisco Examiner.com.

Following the Forum, the SCFSA produced a Food Forum Report, proposing 11 areas for action to improve the access to healthy local foods and support the agricultural economy of Sonoma County. http://aginnovations.org/images/uploads/SCFSA_Food_Forum_Report_FINAL_062811.pdf

2012 Ventura County Ag Summit

The Ventura Alliance hosted the event, *Ventura County Ag Summit: How the Local Food Movement Can Support Ventura County Agriculture*, in February 2012. The public summit brought together over 250 producers, agricultural support agencies, elected officials, educators, food distributors, labor advocates and consumers. Panelists and speakers included the Ventura County Agricultural Commissioner and Public Health Officer, the Farm Bureau of Ventura County, USDA Rural Development Director Glenda Humiston, the Deputy Director for Los Angeles Unified School District's Food Services Department and many more. California Secretary of Food and Agriculture, Karen Ross, gave the keynote address. In addition to building local awareness and engagement in sustainable food system issues, the Summit provided direction for the Alliance.

The need for education about agriculture surfaced at the Summit, and VAFA responded by forming an Ag Education Committee. Members of the committee hosted a forum with local agricultural educators on November 1st to assess the status of local ag education efforts, determine where there were gaps, and asses the role of the VAFA Ag Education Committee for building bridges.

In December 2012, the Ventura AFA released a report on the Ag Summit and the work the Alliance has done since this incredible event. In response to the Summit Findings, the Alliance launched a series of efforts, including:

- Forming an Ag Education Committee that is working to identify priority educational projects that will bolster the local agriculture industry;
- Hosting a listening session for local producers to identify potential actions aimed at reducing the regulatory burden while maintain environmental standards;
- Hosting a convening of 50 agricultural educators to begin assessing educational resources that could be leveraged for agriculture in Venture County http://aginnovations.org/articles/view/ventura_ag_summit_success/

2012 Santa Barbara Farm-to-Fork, Closing the Loop, A Day in the Fields

SBAFA began the *Farm to Fork* series on March 26th and April 4th with two forums describing local agricultural conditions within Santa Barbara County. Over 200 people attended. The series continued on June 4th & September 10th, when over 70 people participated in the bus tours in North & South Santa Barbara County. The tours engaged members of the public by physically taking them to various farms throughout the county, exposing them to different scales and methods of production of exclusively specialty crops. All participants walked away with a broader understanding of some of the farming and farm-related practices taking place in their own backyards.

The Alliance held a follow-up tour called "A Day in the Fields" in September 2012, visiting three different farming operations in the county. Attendees candidly discussed issues with producers such as food safety, labor shortages and critical immigration issues. The tour provided some specific next steps for the SBAFA, which will be working to address these issues at a local level in 2013 and 2014.

In conclusion of the Alliance's yearlong "Farm-to-Fork" series, two panel discussions were held in January 2012, entitled "Closing the Loop," focusing on the role of consumers supporting local producers. Panelists included local producers, health workers, food procurement and food service staff from UCSB and local school districts, restaurant owners, and more. The audience came away with a better understanding of how they can vote with their forks and make a difference for the local food economy.

2012 San Mateo County Agricultural Workshop
Keeping Land in Agriculture: an event co-sponsored by San Mateo County Supervisor Don Horsley and the SMFSA to convene decision-makers, growers and land trusts to explore how to preserve ag land resources in the County.

2012 Santa Clara Healthy Communities Forum
This event was part of a statewide initiative of public forums being held county by county to target decision makers, community leaders, developers, housing advocates and more, to focus on how various facets of the health of Santa Clara cities – economic, environmental and social – intersect. The Alliance hosted the Healthy Communities Forum in November 2012, and is planning a second event in the Fall of 2013 to review the results of the Santa Clara County Food System Assessment. The event will help clarify the challenges associated with the current food system, and provide recommendations for policy makers and individuals to help improve the system. http://aginnovations.org/alliances/santaclara/

2013 Sonoma County Food Action Plan Forums
As part of the Food Action Plan implementation phase, the Food System Alliance is hosting four community forums focused on each of the four action areas of the FAP. These convenings will bring the community together to articulate the action required for adoption and implementation of key priorities and goals in each area. At each event, an Action Team will be formed as an ad-hoc committee of the Alliance to carry out the work set in motion during the forum. On September 16th, 2013, nearly 100 community leaders came together to kickoff the Forum Series and get to work on the Healthy Eating pillar of the Food Action Plan. In partnership with the Sonoma County Healthy Eating Active Living Community Health Initiative, the forum focused on **FAP Goal 5.5: Identify and support innovative strategies to increase the retail availability and affordability of healthy, local food and beverages**. Following several compelling and informative presentations, attendees participated in an extensive workgroup process to identify targeted solutions and opportunities to be advanced throughout the county. At the end of the day, the Healthy Eating Action Team was launched.

Attachment B: California Food System Alliance Network

Projects, Events & Accomplishments Supporting Specialty Crop Agriculture

(Oct 2013 - Oct 2014)

2014 Contra Costa County Food System Assessment (Ongoing)
In early 2014, the Contra Costa FSA came to a consensus to develop a local food assessment. This will be a collaborative effort between the Food System Alliance and other community stakeholders. The intention of the assessment is to explore current gaps and opportunities as it pertains to specialty crop production. These findings and the corresponding analysis and recommendations will further fuel the Alliance work in the county.

2014 San Mateo 100 Water Ponds Project (Ongoing)
In partnership with the San Mateo Resource Conservation District, the San Mateo County Food System Alliance plans to support the development or improvement of 100 water storage ponds within the county. This project is intended to serve local producers, including specialty crop block growers. The Alliance will take on the development and implementation of the plan in 2014, including finding funding and allies for the planning, design, water rights, and permitting.

2013 Santa Barbara Agriculture Economic Viability Study (Ongoing)
This collaborative effort between the Santa Barbara Agricultural Commissioner's Office, the Santa Barbara Ag Futures Alliance, and the Santa Barbara Foundation will emphasize agriculture, including specialty crop efforts, as one of the most economically viable products of the County. An ecosystem services component is also intended to be included, which demonstrates the symbiotic relationship between environmental sustainability and agriculture.

2014 Santa Clara Agricultural Land Protection Policy (Ongoing)
The SCCFSA recognizes the importance of protecting farmland and its impacts all parts of the food system, including local food markets, food access, food justice, and of course, protecting Santa Clara's agriculture industry. In order to be prepared to engage on this issue, the Alliance plans to educate Alliance members on critical land use topics and concepts in order to effectively develop and advocate for an agricultural land protection policy.

2013 Santa Clara General Health Plan Element (Ongoing)
Working with the Santa Clara County Department of Public Heath, the SCCFSA provided input on Health Eating/Food Access/Sustainable Food Systems Section of the Health Element for the General Plan. Alliance members reviewed and generated feedback on the preliminary draft of the Health Eating/Food Access/Sustainable Food Systems Section of the Health Element for the General Plan, and committed to provide additional support to the County Health Department wherever necessary.

2014 Sonoma County Food Action Plan City Endorsement Strategy (Ongoing)
Beginning at the end of 2013, the SCFSA formulated an implementation strategy for the Food Action Plan. The City Endorsement Strategy is an intrinsic part of this action that requires collaboration and advocacy with elected officials and decision makers. The FSA encourages cities to commit to increasing the sourcing of locally produced specialty crops; reduce unnecessary and overly complex regulatory hurdles; and protect land for farming.

2014 Ventura County SOAR Advocacy (Ongoing)
Given local pressures for development, the Ventura Alliance recognizes the importance of renewing SOAR in order to protect and maintain its rich agricultural land. Prior to formulating an action plan, the Alliance will schedule a number of information sessions in order to properly understand the issue. In a county where the majority of agricultural production consists of specialty crops, this advocacy campaign would help to bolster the awareness and support for the renewal of SOAR until 2050 in support of all the local specialty crop producers.

2014 Yolo Ag Futures Alliance and UCCE: UC Davis Farmer Feedback Survey (ongoing)
https://www.surveymonkey.com/s.aspx?sm=5r07vfuiOmAjrIlc6gFWow%3d%3d

EVENTS & PRESENTATIONS BY ALLIANCES

Fresno County Alliance Food Tours. The Fresno FSA met and toured a food bank and a Food Service Department within a Kerman School District facility in order to gain more of an understanding about the food chain and the disbursement of specialty crops to County citizens

Santa Clara FSA In collaboration with SPUR, the SCCFSA hosted a public event in order to discuss the Food System Assessment and its key findings

Sonoma FSA direct participation in Daily Acts' Community Resiliency Challenge http://www.dailyacts.org/crc

Sonoma FSA Sponsors the Sustainable Enterprise Conference
http://sustainableenterpriseconference.com/sponsor/1243/sonoma-county-food-system-alliance

Sonoma FSA Co-hosts and participates at Farmers Guild events, including regular meetings, scholarship fundraisers and Guild-Raising (http://www.farmersguild.org/guild-raising-2014.html)

SCFSA supported UCCE's Sonoma County Drought Workshop

Ventura County Ag Futures Alliance Second Annual Agricultural Education Forum

Ventura County Ag Futures Alliance Alumni Reunion

ALLIANCE PRESENTATIONS WITH THE COMMUNITY

Santa Clara County Food System Assessment presentation to the Open Space Authority Planning Commission

Sonoma County FSA Food Action presentations to
- Mendocino County Food Policy Council
- Sebastopol Grange
- Gold Ridge Resource Conservation District
- Healthy Action City Council Group
- February and March Ag Innovations Network Alliance Network Salons
- Portrait of Sonoma County Leadership Team

SCFSA presents at two sessions at the Sustainable Enterprise Conference

Ventura County AFA presents findings of Ag Education survey to ag educations and growers in the County

San Diego FSA Panel at Slow Food San Diego Good Food Community Fair
http://www.slowfoodurbansandiego.org/ai1ec_event/good-food-community-fair/?instance_id=3379

Fresno County Food System Alliance- Farm to School Training & Mixer
Connecting local farmers, food service directors and distributors) hosted in partnership with Fresno County Health Dept. & Food Trust, September 2014

San Diego Food System Alliance Presentation to Center for Nutrition and Activity Promotion (CNAP), August 2014

Attachment B: California Food System Alliance Network
Projects, Events & Accomplishments Supporting Specialty Crop Agriculture
(Oct 2014 - June 2015)

2014 Contra Costa County Food System Assessment (ongoing)
In early 2014, the Contra Costa FSA came to a consensus to develop a local food assessment. This will be a collaborative effort between the Food System Alliance and other community stakeholders. The intention of the assessment is to explore current gaps and opportunities as it pertains to specialty crop production. These findings and the corresponding analysis and recommendations will further fuel the Alliance work in the county.

2014 Fresno Food System Alliance Food Service Director Survey
A survey for food service directors was conducted in 2014 to measure how involved school districts in Fresno County were in F2S activities. Fresno Unified, one of the largest school districts in the County with more than 50 schools, reported that before the 2013/2014 school year, only a few of their schools were involved in F2S activities. For their 2013/2014 school year, the district reported an increase in local purchases of fruits, vegetables, grains, and dairy products. The district spent roughly 30% of their total food costs and 28% of their total produce cost on locally sourced products. Fresno Unified plans to make more locally produced purchases in the future and is striving to get more involved in F2S activities.

2014-15 San Diego Action Plan (ongoing)
The Alliance created a one-year action plan beginning in March 2014. Aspects of the plan included Production & Procurement, Mapping and Access. The Production & Procurement Committee is working toward increasing the number of Specialty Crop Farmers in San Diego County. The Access Committee is working to link local producers with local markets.

San Diego Support for a Differential on Ag Water Pricing (Oct 2014)
In July of 2014 the SDFSA began educating itself about the Differential for Ag Water Pricing. The program, run through the SD County Water Board is up for review in 2015 with decision by Dec. 2015 about the existence of the program in various capacities. The Alliance will make a decision in Nov. 2014 about its support for the Differential. It is likely that the Alliance will support the differential program as it currently exists and recommend an extension of the program for another 5 years.

2014 San Mateo 100 Water Ponds Project (ongoing)
In partnership with the San Mateo Resource Conservation District, the San Mateo County FSA is supporting the development or improvement of 100 water storage ponds within the county. This project is intended to serve local producers, including specialty crop block growers. The Alliance will take on the development and implementation of the plan in 2014, including finding funding and allies for the planning, design, water rights, and permitting.

2015 San Mateo Local Food and Farm Bill Planning Process (ongoing)
The SMFSA is currently exploring the development of a Local Food and Farm Bill. The idea surfaced from an Idea Hack hosted by The Mixing Bowl. Conversations have just begun so there is much to be determined. The group is currently looking to the Federal Farm Bill and the Sonoma County Healthy and Sustainable Food Action Plan for guidance on framing and content.

2015 San Mateo Ag Viability: Market Coordinator Position being developed by SMFSA

2014 Santa Clara Agricultural Land Protection Policy (ongoing)
The SCCFSA recognizes the importance of protecting farmland and its impacts all parts of the food system,

including local food markets, food access, food justice, and of course, protecting Santa Clara's agriculture industry. In order to be prepared to engage on this issue, the Alliance plans to educate Alliance members on critical land use topics and concepts in order to effectively develop and advocate for an agricultural land protection policy.

2014-15 Santa Clara Agricultural Land Protection Policy
The SCCFSA recognizes the importance of protecting farmland and its impacts all parts of the food system, including local food markets, food access, food justice, and of course, protecting Santa Clara's agriculture industry. In order to be prepared to engage on this issue, the Alliance plans to educate Alliance members on critical land use topics and concepts in order to effectively develop and advocate for an agricultural land protection policy.

2013 Santa Clara General Health Plan Element (ongoing)
Working with the Santa Clara County Department of Public Heath, the SCCFSA provided input on Health Eating/Food Access/Sustainable Food Systems Section of the Health Element for the General Plan. Alliance members reviewed and generated feedback on the preliminary draft of the Health Eating/Food Access/Sustainable Food Systems Section of the Health Element for the General Plan, and committed to provide additional support to the County Health Department wherever necessary.

2014 Sonoma County Food Action Plan City Endorsement Strategy (ongoing)
Beginning at the end of 2013, the Sonoma County Food System Alliance formulated an implementation strategy for the Food Action Plan. The City Endorsement Strategy is an intrinsic part of this action that requires collaboration and advocacy with local elected officials and decision makers. The Alliance encourages local cities to commit to increase the sourcing of locally produced fruit, vegetables, and nuts; reduce unnecessary and overly complex regulatory hurdles; and protect land for farming.

2014 Sonoma County Food System Alliance Pillar Teams (ongoing)
The Ag & Natural Resources Team supporting a farmer needs assessment/survey project. The Economic Vitality Team supporting an effort to shift 10% of local purchasing to local products in 10 years.

2015 Sonoma County Food Action Plan "Growing Our Farms" Summit (video)
The SCFSA hosted a successful community forum to connect emerging farmers with landowners and ag support agencies in Sonoma County. The high cost of For 6 months, the Ag & Natural Resources Committee of the Food System Alliance collaborated with over 10 key agricultural support entities to produce the event.

2014 Ventura County SOAR Advocacy (ongoing)
Given local pressures for development, the Ventura Alliance recognizes the importance of renewing SOAR in order to protect and maintain its rich agricultural land. Prior to formulating an action plan, the Alliance will schedule a number of information sessions in order to properly understand the issue. In a county where the majority of agricultural production consists of specialty crops, this advocacy campaign would help to bolster the awareness and support for the renewal of SOAR until 2050 in support of all the local specialty crop producers.

2014 Yolo Ag Futures Alliance and UCCE: UC Davis Farmer Feedback Survey (ongoing)
EVENTS & PRESENTATIONS HOSTED BY ALLIANCES
Sonoma County Food System Alliance

- Taste the Possibilities: Adding Value to Your Ag Business (workshop), UC Cooperative Extension and Department of Health Services http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=15667
- North Bay iHub Innovation Week 2014; Go Local, UCCE, https://sonomacounty.golocal.coop/stories/north_bay_ihub_innovation_week_2014/831/
- FAP Presentation to Sebastopol Grange; Ag Innovations Network, http://www.waccobb.net/forums/showthread.php?104768-Seb-Grange-monthly-gathering-Tues-April-29-

with-Joseph-McIntyre-of-SC-Food-System-Alliance

- Interfaith Sustainable Food Collaborative – Harvest the Bounty Celebration http://www.interfaithfood.org/
- Interfaith Sustainable Food Collaborative Annual Conference https://www.marinifc.org/community-events/interfaith-sustainable-food-collaboratives-3rd-annual-conference
- Incubator Farm Community Meeting (Sonoma County Ag & Open Space District, UCCE); http://www.sonomacountygazette.com/cms/pages/sonoma-county-news-article-3406.html
    - Project Brief (UCCE/SCAPOSD), http://www.sonomaopenspace.org/docManager/1000002781/OSD-UCCE_Young-Armos-Mtg_final_20150114.pdf
    - Press Democrat http://www.pressdemocrat.com/sports/college/3348107-184/agriculture-briefs
- Sonoma County Hunger Index Forum (Sonoma County Food System Alliance, Sonoma County Human Services Department, Redwood Empire Food Bank, Council on Aging)
  http://www.pressdemocrat.com/news/local/3551366-181/sonoma-county-service-agencies-grapple
- Presentation to the Cloverdale City Council, Food Action Plan
- Presentation to the Healdsburg City Council, Food Action Plan
- Presentation to the Petaluma City Council, Food Action Plan

Attachment C: California Food System Alliance Network
Media & Publications (Oct 2012 - Oct 2013)

MEDIA COVERAGE OF ALLIANCE WORK

2013 Fresno FSA Farm-to-School successes featured in the California Farm-to-School Network newsletter
http://us2.campaign-archive1.com/?u=58aa5ddbd58e183ba415d8433&id=1f428b4f4d

2013 Feature on Sonoma County FSA on KRCB Television.

2013 (Spring) San Diego Food System Alliance featured in Edible San Diego
https://www.dropbox.com/s/ubyb60k3pxqgr7t/Edible%20San%20Diego%20Spring%202013.png

2013 (February) San Diego FSA featured in Ocean Beach People's Co-op newsletter (14,000 distribution)
https://www.dropbox.com/s/k5p6op58ec8lu2v/OBCoopFeb2013.pdf

2012 San Diego FSA featured in Childhood Obesity Initiative newsletter
https://www.dropbox.com/s/tudj78aqh1hxlwo/COI_Dec2012.pdf

2013 Sonoma County Food Action Plan featured in GoLocal newsletter and website:
http://sonomacounty.golocal.coop/stories/sonoma_county_food_system_alliance_next_steps/691/

2013 Fresno Farm to School Committee Featured on Channel 30 News Ag Watch
http://abclocal.go.com/kfsn/story?section=news/ag_watch&id=9053658

2013 Fresno Farm to School Committee Featured on NPR Valley Public Radio http://kvpr.org/post/reedley-farmer-goes-farm-school-strawberries

2013 Santa Barbara Buffer Zone Ordinance Victory Featured in the Santa Barbara Independent
http://www.independent.com/news/2013/apr/17/agricultural-buffer-zone-ordinance-approved-santa-/

2013 in AgAlert (California Farm Bureau publication) featuring Santa Barbara Buffer Zone Ordinance victory
http://www.agalert.com/story/?id=5457

2013 Santa Barbara Buffer Zone ordinance featured in the Santa Maria Times
http://santamariatimes.com/news/local/govt-and-politics/sb-county-supervisors-approve-ag-buffer/article_2b7f214c-a1a3-11e2-a5e3-001a4bcf887a.html

2013 Santa Clara FSA Member Highlighted in Article about Immigrant Growers

2013 Santa Clara Assessing Santa Clara County's Food System, SPUR http://www.spur.org/events/2013-08-15/assessing-santa-clara-county-s-food-system

2013 Sonoma County's Food Action Plan Featured in the North Bay Bohemian
http://www.bohemian.com/northbay/local-food-inc/Content?oid=2332697

2013 Yolo/Solano “Farmbudsman” Article Highlights New Hire in the Daily Republic
http://www.dailyrepublic.com/news/business-local/farmbudsman-ready-to-help-farmers-navigate-system/

2013 Yolo/Solano “Farmbudsman” Article Highlights New Hire in the Times-Herald
http://www.timesheraldonline.com/rss/ci_22846990?source=rss

2012 Fresno FSA Releases Op-Ed in Response to NY Times
http://aginnovations.org/images/uploads/Final_Fresno_FSA_Op_Ed_NYT_Mag_Bittman_The_Valley_is_Forging_a_Sustainable_Food_System.pdf

2012 Ventura Ag Summit Featured on KCLU Radio http://www.kclu.org/2012/02/21/agricultural-alliance-conference-in-ventura-county-looks-at-getting-more-fresh-produce-into-homes-of-those-in-need/

2012 Ventura Ag Summit Featured in the Ventura County Star
http://www.vcstar.com/news/2012/feb/17/summit-explores-how-to-keep-farming-a-presence/

2012 Ventura Ag Summit Featured in the Camarillo Acorn http://www.thecamarilloacorn.com/news/2012-02-24/Front_Page/Countys_ag_industry_remains_big_business.html

PUBLISHED REPORTS & ASSESSMENTS PRODUCED BY ALLIANCES

2013 San Diego FSA Building a Thriving San Diego Regional Food System
http://healthyworks.org/sites/default/files/PrioritiesforAction.pdf

2013 San Mateo: Farming and Farmland: The Pie Ranch Access to Land Project http://aginnovations.org/images/uploads/FarmlandforFarming-1.pdf

2013 Santa Clara County Food System Assessment
https://drive.google.com/file/d/0B8dLrJVrV_A6ckQtcWRQdEFmOGc/view?usp=sharing

2013 Sonoma County Healthy & Sustainable Food Action Plan
http://aginnovations.org/images/uploads/FAP2_HQ.pdf

2012 Ventura Progress Report: Making Connections: How the Local Food Movement Can Support Ventura County Agriculture http://aginnovations.org/images/uploads/VenturaReport_Final-1.pdf

Attachment C: California Food System Alliance Network
Media and Publications (Oct 2013 - Apr 2014)

MEDIA COVERAGE OF ALLIANCE WORK

Santa Clara FSA Food System Assessment Op-Ed in the San Jose Mercury News
http://www.mercurynews.com/opinion/ci_24961696/hunger-silicon-valley-bringing-healthy-food-poor-communities

Santa Clara FSA Towards a Better Food System in Santa Clara County, Committee for Green Foothills
http://www.greenfoothills.org/towards-a-better-food-system-in-santa-clara-county/

Santa Clara FSA Hunger in Silicon Valley: Bringing healthy food to poor communities is a challenge, San Jose Mercury News http://www.mercurynews.com/opinion/ci_24961696/hunger-silicon-valley-bringing-healthy-food-poor-communities

Sebastopol City Councilmember Sarah Glade Gurney on the City's endorsement of the Sonoma County FSA Food Action Plan in the Sonoma County Gazette http://www.sonomacountygazette.com/cms/pages/categories-rtn-sonoma-com-arg1-Communities-arg2-Sebastopol-article-2568.html

Ventura AFA Ag Education Forum featured in the Ventura County Star
http://aginnovations.org/images/uploads/Agricultural_education_network_in_Ventura_County_aims_to_connect_-_Graphic.pdf

Ventura AFA Ag Education Report Press Release
http://aginnovations.org/images/uploads/Ag_Ed_Report_Press_Advisory_FINAL.pdf

PUBLISHED REPORTS & ASSESSMENTS PRODUCED BY ALLIANCES

2014 San Diego County Food System Info-graphic https://magic.piktochart.com/output/709107-flow-2#
(conveys information about the County's food system)

2014 Ventura County: *Ag Education Survey Report: An Advancement of the Understanding of Agricultural Literacy in Ventura County* http://aginnovations.org/images/uploads/Survey_Report_Final1_7_14.pdf

2014 Santa Mateo County Food System Assessment (link TBD)

2014 Fresno County: *Healthfully Processed Foods* (link TBD)

2014 Contra Costa County Website: http://aginnovations.org/alliances/contracosta/

2013 Sonoma County Website: http://sonomacofsa.org/

2013 Sonoma County Food System Alliance Newsletter
https://docs.google.com/file/d/0B8dLrJVrV_A6eVZudURfZVV3YlU/edit?usp=sharing)

ALLIANCE PRESENTATIONS WITH THE COMMUNITY

Santa Clara County Food System Assessment presentation to the Open Space Authority Planning Commission

Sonoma County FSA Food Action presentations to

- Mendocino County Food Policy Council
- Sebastopol Grange
- Gold Ridge Resource Conservation District
- Healthy Action City Council Group
- February and March Ag Innovations Network Alliance Network Salons
- Portrait of Sonoma County Leadership Team

SCFSA presents at two sessions at the Sustainable Enterprise Conference

Ventura AFA presents findings of Ag Education survey to agricultural educations and growers in the County

ALLIANCE APPEARANCES BEFORE ELECTED OFFICIALS

San Diego FSA letter to Supervisor Ron Roberts in order to recommend actions that should be taken by the County in order to ensure long-term economic sustainability and accessibility of food production

The Santa Clara County Alliance met with Congressman Honda (CA-17) to advocate for recommendations derived from the Food System Assessment and to introduce him to the Food System Alliance in general

Sonoma County FSA met with the Sonoma County Board of Supervisors regarding Food Day 2013

SCFSA appeared before the following entities in order to discuss a Food Action Plan endorsements/partnerships

- Sebastopol City Council http://ci.sebastopol.ca.us/sites/default/files/events-and-meetings/agenda_item_number_7_presentation_food_alliance_food_action_plan.pdf
- Sonoma City Council
- Healdsburg City Councilmember (collaboration to plan endorsement/presentation meeting)
- Sonoma County FSA received a Food Day Gold Resolution from the Sonoma County Board of Supervisors
- SCFSA Ag and Natural Resources Committee
- Met with Santa Rosa Mayor and Supervisor Zane to discuss Urban Agricultural Zones (UAZs)
- Meeting with Assembly Member Levine

OTHER ALLIANCE METHODS OF PROMOTING AND EDUCATING AROUND SPECIALTY CROPS

Contra Costa County

- Sustainable Contra Costa Network http://sustainablecoco.ning.com/
- CCFSA member Pamela Sing from Wellness City Challenge creates an information website http://21stcenturyagriculture.com/contra_costa_county_food_system_alliance
- References in stories:
    - Contra Costa Times http://aginnovations.org/alliances/contracosta/

- Greenbelt Alliance http://www.greenbelt.org/general/brentwood-general-plan-pressures-farms/

San Diego County Food System Alliance Facebook Page https://www.facebook.com/sandiegocofsa

San Mateo County References:

- San Mateo County Health System website: http://www.smchealth.org/node/117
- Get Healthy San Mateo County website: http://gethealthysmc.org/SustainableFoodResearch
- Greenbelt Alliance: http://www.greenfoothills.org/projects/san-mateo-county-food-system-alliance-fsa/

Santa Clara County

- Greenbelt Alliance Blog http://www.greenbelt.org/general/rethinking-santa-clara-food/
- Greenbelt Alliance http://www.greenfoothills.org/towards-a-better-food-system-in-santa-clara-county/
- Santa Clara University Department of Environmental Sciences http://www.scu.edu/cas/ess/?c=18762
- Silicon Valley Business Journal http://www.bizjournals.com/sanjose/print-edition/2014/04/04/veggielution-community-farms-amie-frisch-women-of.html?page=2

Go Local Sonoma County
https://sonomacounty.golocal.coop/stories/sonoma_county_food_system_alliance_next_steps/691/

Attachment C: California Food System Alliance Network
Media & Publications (Apr 2014 - Oct 2014)

Ag Innovations Network created and maintained websites for all operating Food System Alliances. Staff curated, posted and distributed content to websites and newsletters, drafted official correspondence, and provided regular communications support to Alliance members.

MEDIA COVERAGE OF ALLIANCE WORK

2014 San Mateo FSA Facebook Page
https://www.facebook.com/pages/San-Mateo-County-Food-System-Alliance/374508219253965

2014 San Mateo FSA The 'Foodshed' and the Common Interest: Powell's Vision Revisited
http://environment.yale.edu/envirocenter/post/the-foodshed-and-the-common-interest-powells-vision-revisited /

2014 San Mateo FSA (mentioned in briefing for 100 Ponds Project)
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0CD4QFjAF&url=http%3A%2F%2Fncsmc.ca.lwvnet.org%2Ffiles%2F2014_the_100_ponds_project_description.pdf&ei=9ss1VPCBNcPB8QH4yIH4CA&usg=AFQjCNH5tzayj_ZMz6h4JpwY9_U3H62MOw

2014 San Mateo FSA Local Food Producers Honoring 'Food Day'
http://www.allthingsnow.com/day/unknown/shared/11830732/Local+Food+Producers+Honoring+%27Food+Day%27
2014 San Mateo FSA La Honda garden gains helping hands
http://www.hmbreview.com/news/la-honda-garden-gains-helping-hands/article_8a102dfc-44d4-11e4-b671-47e6d86fff3e.html

2014 Santa Clara County FSA - SC3 Releases Healthy Lands & Healthy Economies Initiative
http://aginnovations.org/articles/view/sc3_releases_healthy_lands_healthy_economies_initiative_-_natures_valu/

2014 Scheer leaving Santa Clara County Farm Bureau
http://www.gilroydispatch.com/news/community/scheer-leaving-santa-clara-county-farm-bureau/article_309930ae-f7d4-11e3-aa16-0017a43b2370.html

2014 Sonoma County Food System Alliance Bolstering the Food System in Sonoma County, Greenbelt Alliance
http://www.greenbelt.org/blog/bolstering-food-system-sonoma-county/

2014 Sonoma County Food System Alliance - Experiential Learning's Impact on the Local Food System
http://www.sonomacofsa.org/news/details/experiential-learnings-impact-on-the-sonoma-county-food-system

2014 Sonoma County Food System Alliance PPSC aligns with Sonoma County Food System Alliance

2014 Sonoma County Food System Alliance - Farm Girl Cattle Co.
http://www.sonomacofsa.org/news/details/farm-girl-cattle-co

PUBLISHED REPORTS & ASSESSMENTS

San Mateo County FSA Releases Food System Assessment Report
http://aginnovations.org/articles/view/food_system_assessment/

2014 San Mateo County Local Food Feasibility Report Released:
http://aginnovations.org/articles/view/san_mateo_feasibility_study_report_released/

2014 San Diego County Food System Info-graphic https://magic.piktochart.com/output/709107-flow-2

2014 Fresno County: *Healthfully Processed Foods*

2014 Contra Costa County Website: http://aginnovations.org/alliances/contracosta/

2013 Sonoma County Website (expansion): http://SonomaFoodAction.org

2014 Ag Innovations Network Newsletter:
http://aginnovations.org/articles/view/Fall_newswire_5_pivot_points_for_a_healthier_food_system/

2014 Sonoma County Food System Alliance Newsletter
https://docs.google.com/file/d/0B8dLrJVrV_A6eVZudURfZVV3YlU/edit?usp=sharing

Attachment C: California Food System Alliance Network
Media & Publications (Oct 2014 - March 2015)

Prior to the Alliance transition, Ag Innovations Network maintained websites for all operating Food System Alliances. AIN remains a supportive partner to each and continues to post, mention, and coordinate with individual groups when requested/possible.

ALLIANCE WEBSITES ⬩ SOCIAL MEDIA ⬩ NEWSLETTERS

- As part of the transition, each group has/will transition to independent websites (with AIN's support).
- Sonoma County Food System Alliance http://sonomacofsa.org/
- Santa Clara County Food System Alliance http://sccfsa.wix.com/sccfsa
- Contra Costa Food System Alliance http://contracostafsa.wix.com/ccfsa
- Yolo Ag Futures Alliance http://yoloafa.org/
- San Mateo Food System Alliance developing new website sanmateofoodsystemalliance.wordpress.com
- San Diego Food System Alliance launched new website sanmateofoodsystemalliance.wordpress.com

2014 San Mateo FSA Facebook Page https://www.facebook.com/pages/San-Mateo-County-Food-System-Alliance/374508219253965

San Mateo Food System Alliance Endorses the CA Food Policy Council 2014 Legislative Report http://aginnovations.org/articles/view/san_mateo_food_system_alliance_endorses_the_california_food_policy_cou/

Sonoma County Food System Alliance Newsletter (partnership w/Sonoma County Go Local)
- Go Local-SCFSA Newsletter #1: http://campaign.r20.constantcontact.com/render?ca=80b96486-9f47-4a36-bfe0-5205ab352a85&c=0f9eb2f0-349f-11e3-a11b-d4ae5292c4bc&ch=116fc970-349f-11e3-a146-d4ae5292c4bc
- Go Local-SCFSA Newsletter #2: http://campaign.r20.constantcontact.com/render?ca=4126879f-97a7-4024-85b0-aebb1d036b51&c=0f9eb2f0-349f-11e3-a11b-d4ae5292c4bc&ch=116fc970-349f-11e3-a146-d4ae5292c4bc

AG INNOVATIONS NETWORK NEWSWIRE

- January 2015, http://aginnovations.org/articles/view/january_newswire_innovating_in_2015/
- Fall - Winter 2014, http://aginnovations.org/articles/view/Fall_newswire_5_pivot_points_for_a_healthier_food_system/

Sonoma County Food System Alliance Growing Our Farms Summit
- Press Democrat article. http://www.pressdemocrat.com/business/3782979-181/agriculture-briefs
- KRCB Radio Spot, http://krcb.org/krcb-news-feed/connecting-new-farmers-with-land

Sonoma County Land for Food Production; The "County Land for Food Production" report approved on March 10, 2015 by Sonoma County Board of Supervisors http://www.sonomacountygazette.com/cms/pages/sonoma-county-news-article-3753.html

Our Food System, KRCB, Sonoma County Food System Alliance members

Attachment C: California Food System Alliance Network

Media & Publications (March 2015 - June 2015)

ALLIANCE WORK: MEDIA COVERAGE, REPORTS & EVENTS

Sonoma County Food System Alliance, "Growing Our Farms Forum"
http://ucanr.edu/sites/BFRSOCO/Land_Opportunities/
http://www.aginnovations.org/post/2015-05-26/growing-our-farms-a-local-food-system-forum

San Mateo Food System Alliance Facebook Page https://www.facebook.com/pages/San-Mateo-County-Food-System-Alliance/374508219253965

San Diego Food System Alliance (new website) http://www.sdfsa.org/

San Diego Food System Alliance Facebook Page https://www.facebook.com/sdfoodsystemalliance

APPENDIX A

Water Use Efficiency

for the

San Joaquin Valley

Specialty Crop Program

Water Use Efficiency
for the
San Joaquin Valley
Specialty Crop Program

This book is published by the Center for Irrigation Technology (CIT) at California State University, Fresno as part of the **Water Use Efficiency Education for the San Joaquin Valley Specialty Crop Program**, with funding from the California Department of Food and Agriculture (CDFA) Specialty Crop Block grants. This program is intended for growers within the San Joaquin Valley. This book presents concepts and practices that promote "efficient" agricultural water use and conservation.

The Center for Irrigation Technology Water Use Efficiency Education for the San Joaquin Valley is a comprehensive effort to improve irrigation efficiency in California's San Joaquin Valley and throughout the state. Through seminars and self-guided work, this program is designed to educate the public about irrigation and water use efficiency for specialty crops.

INTRODUCTION

The Center for Irrigation Technology (CIT)

Created in 1980, the Center for Irrigation Technology (CIT) is internationally recognized as an independent testing laboratory, applied research facility and educational resource. CIT is a part of the Jordan College of Agricultural Sciences and Technology and one of the water programs of California State University, Fresno. The programs also include the International Center for Water Technology (ICWT), the California Water Institute (CWI) and the newly established AgWaterEnergy Center. All activities reflect the need to integrate agricultural, environmental, and urban concerns.

CIT programs cover four major areas: hydraulics laboratory testing, field research, analytical studies and special projects. CIT's state-of-the-art testing facilities provide equipment testing and evaluation for both public agencies and private businesses. The CIT lab is IAPMO-certified to test for EPA WaterSense® labeling. The center conducts education programs for irrigation professionals and growers on a wide variety of topics including pump efficiency, irrigation technology and water management.

Mission

CIT is dedicated to advancing irrigation technology, water/energy management practices, and equipment standards.

Goals

The goal of this Water Use Efficiency in the San Joaquin Valley program is to increase the knowledge of growers and irrigation professionals who attend one or more of the seminars by providing the latest information on efficient irrigation practices, new innovations, and government and legislative issues.

Seminars

As part of this program, seminars will be given on the following topics:

1. Irrigation Systems
2. System Efficiency
3. Different Irrigation Systems
4. System Maintenance
5. Scheduling and Wateright
6. Water Sources
7. Monitoring Tools
8. Center Pivots

Using this Book

What is the purpose of this book?

The main purpose of this book is to present and discuss the basics of water use and irrigation system efficiency. It is not intended to present a technical discussion of irrigation efficiency or water use efficiency. Rather it is intended to provide the basic information needed to understand what savings are possible by using different methods, practices and systems.

Who is this book intended for?

This book is published by the Center for Irrigation Technology as part of the Water Use Efficiency Education for San Joaquin Valley Specialty Crop growers. This program was developed and is managed by CIT on the campus of Fresno State and is funded by the California Department of Food and Agriculture. It is intended for growers, water agencies, and agricultural professionals. The curriculum was developed to promote the use of the best management practices, technologies and methodologies needed to conserve water. This education program is intended for specialty crop growers, agricultural professionals and their affiliates. This book presents concepts and practices that can reduce water and energy usage.

How is this book organized?

The book consists of eight sections. The last section includes helpful information including web sites for additional information.

Section 1: Agricultural Water Consumption in California
Section 2: Improving Irrigation Efficiency
Section 3: Managing an Irrigation Event
Section 4: Irrigation Scheduling
Section 5: Different Types of Irrigation
Section 6: Irrigation System Maintenance
Section 7: Energy and Irrigation
Section 8: Helpful Information

The irrigation water management definitions in Box A will help provide a better understanding of the discussions in this book. Acronyms are listed in Section 8.

Box A – Key definitions

consumptive use – a use of water that removes the water from the system so that it cannot be recovered for reuse by some other entity. Consumptive uses may be beneficial or non-beneficial. A beneficial consumptive use would be crop evapotranspiration.

crop coefficient (Kc) – a dimensionless number between 0.1 and 1.2 used to predict crop water use.

dedicated water – as defined by the Department of Water Resources (DWR) is "water distributed among urban and agricultural uses, used for protecting and restoring the environment, or storage in surface water and groundwater reservoirs. In any year, some of the dedicated supply includes water that is used multiple times (reuse) and water held in storage from previous years. This is about 40 to 50 percent of the total annual water supply received from precipitation and imported from Colorado, Oregon, and Mexico." Context: Water Portfolio"[1]

Dedicated water includes water flowing in the Wild and Scenic Rivers. Many partially used (Eel) or unrestricted (Van Duzen) rivers could have been significantly diverted for use by M&I and/or agriculture. However, these waters have been dedicated by law to the environment. Other examples of dedicated water are the 800,000 acre-feet/year reallocated back to the environment by the Central Valley Project Improvement Act (CVPIA) [2] and the 647,000 AF/year reallocated back to the Trinity River for restoration of that river's fishery.[3,4]

distribution uniformity (DU) – a measure of how evenly water soaks into the ground across a field during the irrigation.

distribution uniformity lower quarter (DUlq) – the most common measure of DU. Divide the average depth infiltrated in the low quarter of the field with the lowest infiltrated depths by the average infiltrated depth in the field.

evapotranspiration (ET) – the amount of water transpired by plants, retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.[1] **Crop evapotranspiration** is specifically denoted by the acronym **ETc**.

irrigation efficiency (IE) – the ratio of applied water that is beneficially used to the total amount of applied water. In some cases, improved irrigation efficiency can prevent or reduce irrecoverable fractions of water and thus, affect water conservation. Major beneficial uses of applied water include crop evapotranspiration, leaching for salinity control, and possibly as an aid in field preparation.

new water – defined in part by DWR as "water that is legally and empirically available for a beneficial use; can be developed through many strategies such as capturing surplus water, desalination of ocean water, and reductions in depletions. (Same meaning as real water)." [1]

recoverable fractions/irrecoverable fractions – in the context of this paper, these are the fractions of applied irrigation water that flow off a field and result in no benefit to the crop or field (i.e., maintaining soil productivity). These fractions can include surface runoff, immediate evaporation during the irrigation event, or percolation below the active root zone of the field. These fractions may be recoverable for reuse (e.g., immediately as a surface runoff flow directed to another field or later as groundwater pumped from an aquifer) or irrecoverable (i.e., they become a depletion of water).

water conservation – any act that serves to prevent an irrecoverable fraction of water and/or reduces potential alterations of water quality that would prevent some specific type of subsequent reuse.

1. California Water Plan Update 2009 Glossary. Department of Water Resources. Resources Agency. State of California
2. Central Valley Project Improvement Act, Title 34, Public Law 102-535, October, 1992.
3. Record of Decision. Trinity River Mainstem Fishery Restoration. Final Environmental Impact Statement/Environmental Impact Report. U.S. Department of the Interior. December 2000
4. Westlands Water District vs. U.S. Department of Interior. Case Nos. 03-15194, 03-15289, 03-15291 and 03-15737. Argued and Submitted Feb. 9, 2004 - July 13, 2004, United States Court of Appeals, Ninth Circuit

SECTION 1: AGRICULTURAL WATER CONSUMPTION IN CALIFORNIA

How much water does agriculture use in California?

The question of how much water California agriculture actually uses is dependent upon whom the question is directed to. Different agencies have different views. The 2009 Update to the Department of Water Resources (DWR) California Water Plan (CWP) utilizes an eight-year average of dedicated water balances for California. Table 1 summarizes the data collected by DWR from 1998 to 2005 (Table 1).

Table 1 – Summary of estimates of the eight-year average dedicated water balances in California for 1998 through 2005

MILLION ACRE-FEET	EIGHT-YEAR AVERAGE		
	Applied Water	Net Use*[1]	Depletion**[1]
Total Urban Use	**8.75**	**6.53**	**6.51**
Total Agricultural Use	**33.22**	**25.80**	**24.66**
Environmental Uses			
Instream			
Applied Water	7.17		
Outflow		2.69	2.68
Wild & Scenic			
Applied Water	26.01		
Outflow		20.12	20.12
Required Delta Outflow			
Applied Water	6.64		
Outflow		6.64	6.64
Managed Wetlands			
Applied Water	1.46		
Evapotranspiration of Applied Water		0.62	0.62
E&ET and Deep Percolation to Salt Sink			
Outflow		0.26	
Conveyance Applied Water	0.07		
Conveyance Evaporation and ETAW		0.00	0.00
Conveyance Deep Percolation to Salt Sink		0.00	0.00
Conveyance Outflow		0.00	0.00
Total Managed Wetlands Use	1.53	0.88	0.63
Total Environmental Use	**41.36**	**30.33**	**30.06**
TOTAL USE AND OUTFLOW	**83.33**	**62.66**	**61.24**

* Net water use (demand) – defined by DWR as "The amount of water needed in a water service area to meet all requirements. It includes the consumptive use of applied water, the irrecoverable water from the distribution system, and the outflow leaving the service area. It does not include reuse of water within a service area. *See also* applied water use. Context: Water Portfolio"

** Depletion – defined by DWR as "The quantity of water consumed, discharged to a salt sink within a service area, or moved outside the service area and no longer available as a source of supply within the service area. Context: Water Portfolio"

1. California Water Plan Update 2009 Glossary. Department of Water Resources. Resources Agency. State of California

Reference:
PA_eight_year_balances_3-9-11.XLSX. Bulletin 160 Update 2009 Volume 5 - Technical Guide. Department of Water Resources. Resources Agency. State of California @ http://www.waterplan.water.ca.gov/technical/cwpu2009/

If the discussion is on only consumptive use of agriculture, municipal and industrial water use then agriculture's share is near 80 percent of the total or 24.66 MAF of 31.17 MAF. However, if this percentage is based on total dedicated water supply then agriculture's water use is roughly around 40 percent or 24.66 MAF of 61.24 MAF.

Recoverable versus Irrecoverable Fractions

In 1982, David C. Davenport and Robert M. Hagen from the University of California, Davis (UC Davis) penned the report titled *Agriculture Water Conservation in California, With Emphasis on the San Joaquin Valley* (DH Report). They conceived and coined the concepts of **recoverable and irrecoverable** fractions (volumes of water) which can still be applied today. The fundamental concept of recoverable and irrecoverable is that there are two types of water – water that is used and lost and water that can be recovered and used at a later date.

The key distinction between recoverable and irrecoverable use is whether surface runoff or deep percolation resulting from irrigation on one field (which would be considered an inefficiency) can be recovered and reused for other purposes or for the environment. These **recoverable fractions** aren't true depletions of the water supply, rather they are water that can be used at a different place and different time than the original diversion. In fact, recoverable water may be recovered and reused several times and possibly for different purposes. **Irrecoverable fractions** are the only true actual depletions resulting from inefficiencies. These depletions occur when surface runoff or deep percolation resulting from irrigations move to another water body (non-accessible aquifer, ocean, etc.) that is unusable for some reason.

In summary, the only true depletions (losses) in terms of water volumes are irrecoverable fractions. **All water users should continually strive to minimize irrecoverable fractions.** However, recoverable fractions are just that, recoverable. There may be other undesirable impacts and the range of uses (e.g., irrigation, recreation, human consumption, stock watering) may be diminished with each reuse and recovery, but nonetheless, they are available.

Recoverable versus Irrecoverable Fractions Concepts Illustrated

Figures 1 through 4 visually demonstrate the concepts of recoverable and irrecoverable fractions. The two sets of illustrations are intended to depict two major types of agricultural water use areas in California:

1. Figures 1 and 2 – a **flow-through** system before and after on-farm efficiency improvements
2. Figures 3 and 4 – a **closed-end** system before and after on-farm efficiency improvements

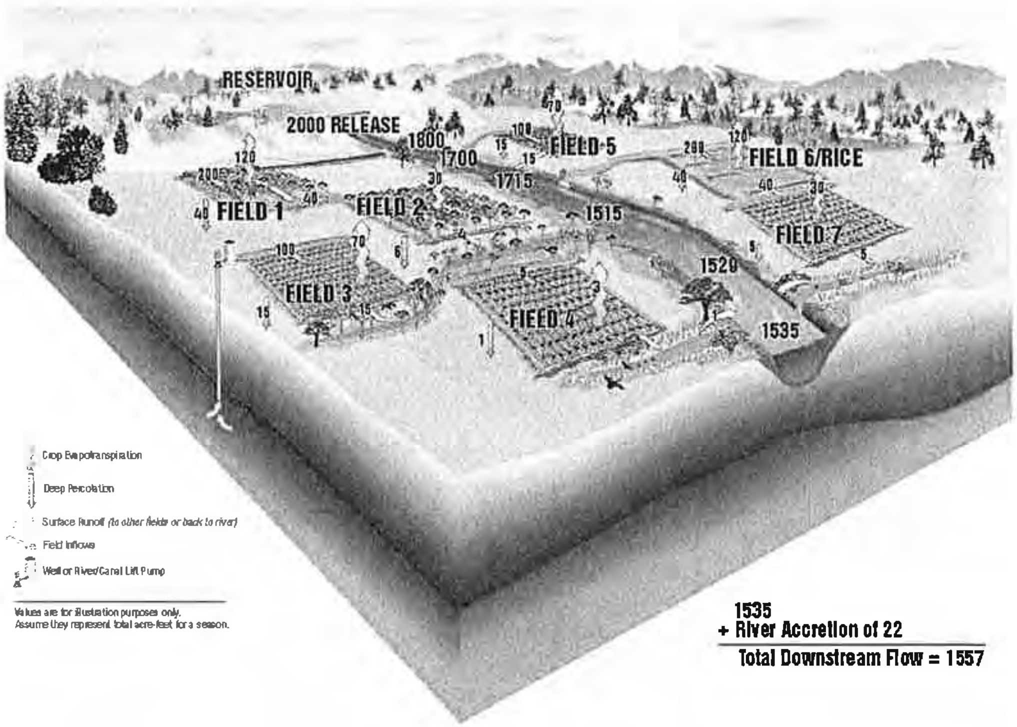


Figure 1 – A flow-through system before on-farm efficiency improvements

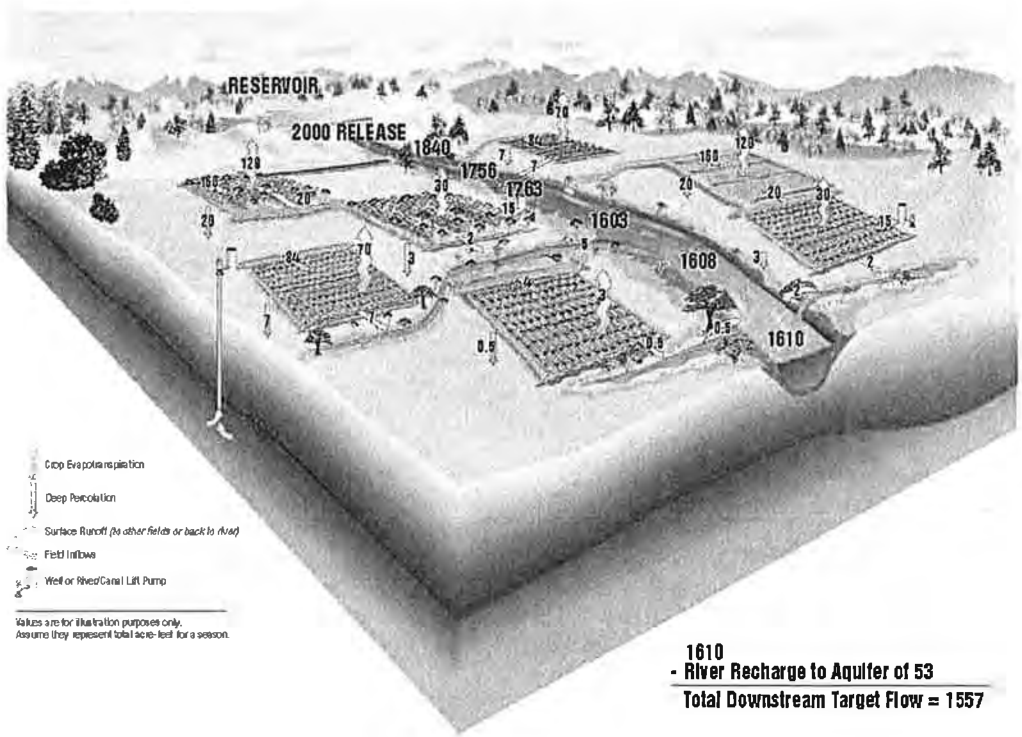


Figure 2 – A flow-through system after on-farm efficiency improvements

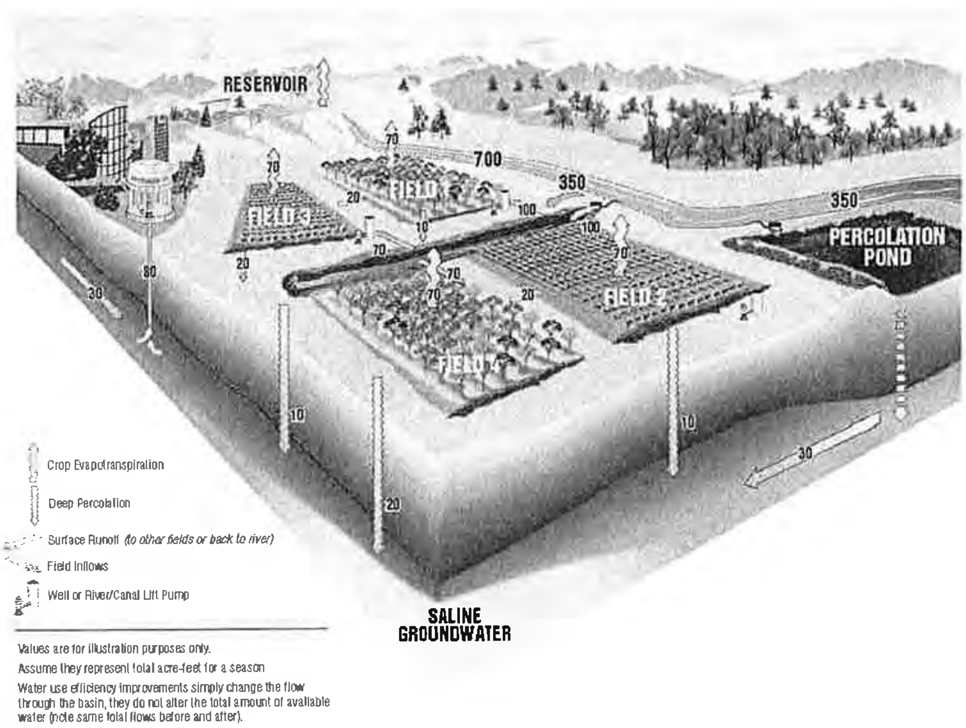


Figure 3 – A closed-end system **before** on-farm efficiency improvements

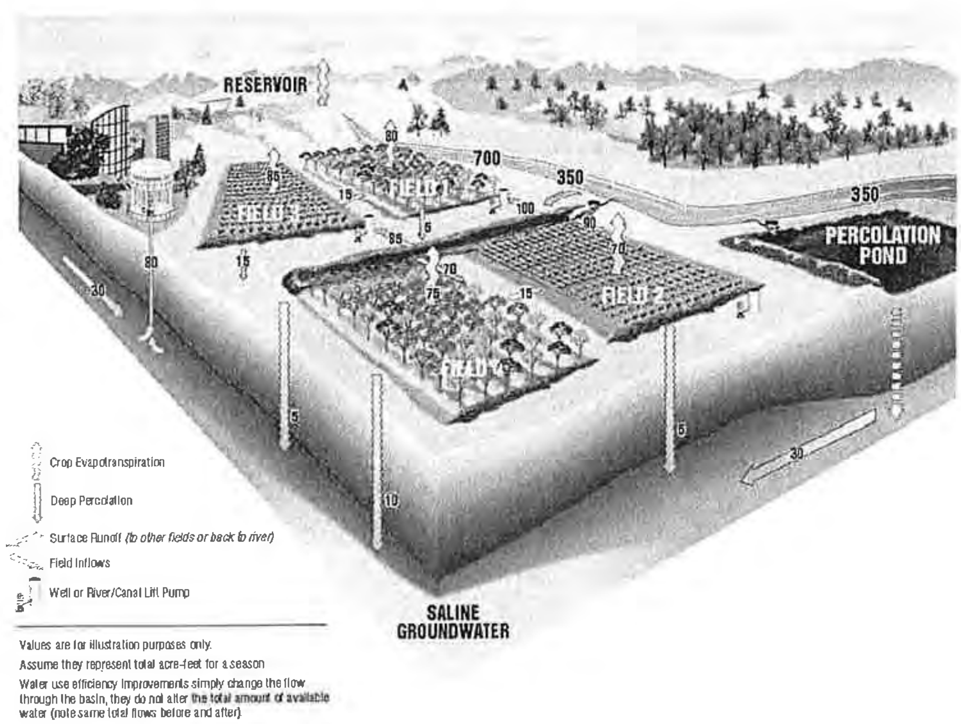


Figure 4 – A closed-end system **after** on-farm efficiency improvements

SECTION 2: IRRIGATION EFFICIENCY

Measuring Irrigation Performance

There are two ways to measure irrigation performance – distribution uniformity (DU) and irrigation efficiency (IE).

Distribution uniformity – a measure of how evenly water soaks into the ground across a field during the irrigation. If eight inches of water soaks into the ground in one part of the field and only four inches in another part of the field that would be poor distribution uniformity (Figure 5). Distribution uniformity is expressed as a percentage between 0 and 100. Although 100 percent distribution uniformity is theoretically possible, it is virtually impossible to attain in actual practice. Good distribution uniformity is critical for reducing deep percolation. The basis for the measurement – the most common measure of DU is to divide the average depth infiltrated in the low quarter of the field with the lowest infiltrated depths by the average infiltrated depth in the field. This is called the **low quarter DU (DUlq)**.

Irrigation efficiency – was defined by the American Society of Civil Engineer's On-Farm Irrigation Committee in 1978 as the ratio of the volume of water which is beneficially used to the volume of irrigation water applied. Beneficial uses may include crop evapotranspiration, deep percolation needed for leaching for salt control, crop cooling, frost control, and as an aid in certain cultural operations. Irrigation efficiencies are also expressed as a percentage between 0 and 100 percent. One hundred percent irrigation efficiency is not theoretically attainable due to immediate evaporation losses during an irrigation. However, there could easily be close to 95 percent IE if a crop was under-watered. In this case, assuming that there was no deep percolation, all water applied and not immediately evaporated would be used by the crop.

First relationship between DU and IE

> ***There must be good distribution uniformity before there can be good irrigation efficiency, if the crop is to be sufficiently watered.***

In Figure 5, the grower has not irrigated sufficiently to supply water to the entire field. Poor distribution uniformity, indicated by the uneven infiltrated water, has resulted in some plants not getting the required amount of water.

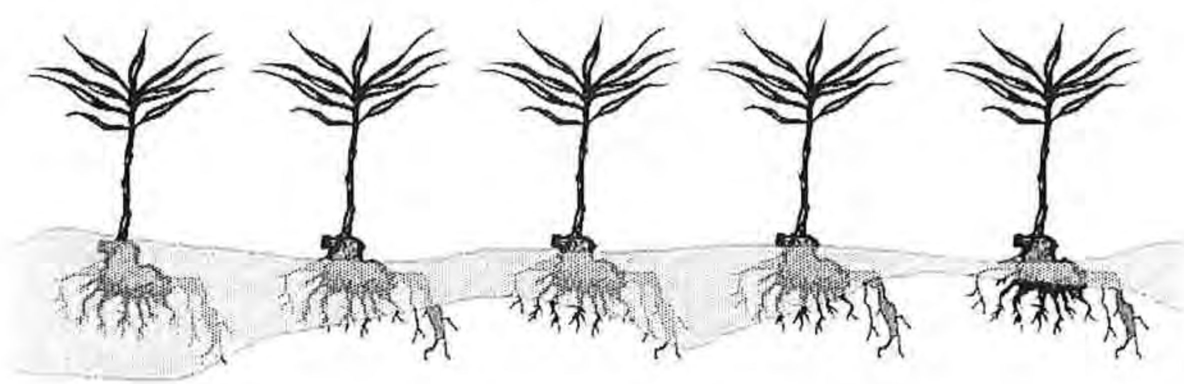


Figure 5 – Depiction of irrigation resulting in poor distribution uniformity

Second Relationship between DU and IE

Good distribution uniformity is no guarantee of good irrigation efficiency.

Figures 6 and 7 show that good distribution uniformity can result in a good irrigation efficiency, but the total amount of water applied must still be controlled. Figure 6 depicts a good irrigation. There was high distribution uniformity as indicated by the flatter infiltrated depth line. About the right amount of water was applied. There is little deep percolation and the entire field is wetted sufficiently. It is assumed that surface runoff was minimal or collected for reuse.

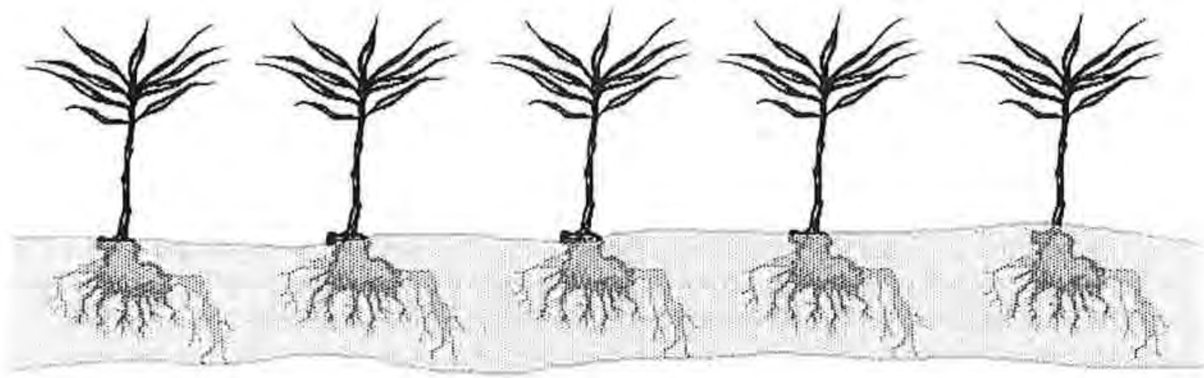


Figure 6 – Depiction of an irrigation sufficiently watering the entire field with good distribution uniformity and irrigation efficiency

Figure 7 depicts an irrigation with the same high distribution uniformity as in Figure 6. However, twice as much water as needed was applied, resulting in low irrigation efficiency. Another practical example of this situation is the grower who is using a well-designed and maintained micro irrigation system. The hardware provides the good distribution uniformity and the potential for high irrigation efficiency. However, if the grower runs the system twice as long as necessary, the potential is not realized.

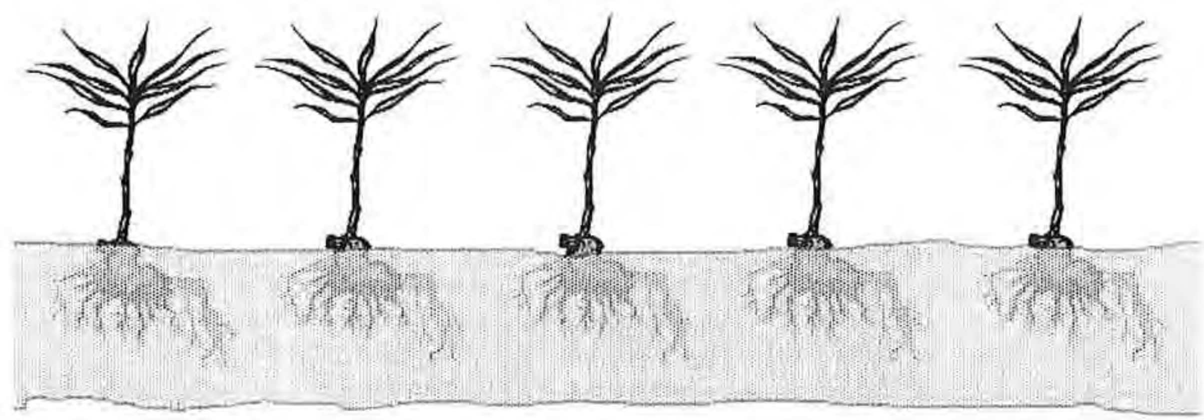


Figure 7 – Depiction of an irrigation resulting in good distribution uniformity but poor irrigation efficiency

Corollary to relationships between DU and IE

> ***If the whole field is to be sufficiently watered, then the distribution uniformity becomes the theoretical upper limit to irrigation efficiency.***

That is why DU is the first aspect examined when trying to improve irrigation performance.

An important result is that if the entire field is assumed to be sufficiently wetted during an irrigation (including water required for leaching) then the distribution uniformity is the upper limit of irrigation efficiency. And it then follows that the first concern when improving irrigation system performance is the distribution uniformity.

Evaluating Irrigation Systems for Distribution Uniformity

There are rational processes that have been developed for evaluating distribution uniformity of most major types of irrigation systems. Many different evaluation programs have been developed all over the world. One of the most well-known was developed by the Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo. In addition, although the ITRC program was the basis for the Mobile Irrigation Laboratories in California, many of the labs have developed their own software and techniques to match conditions in their areas.

Any evaluation process is a statistical process. That is, a sample of the field is taken and the DU for the entire field is inferred from the sample. Practical limitations regarding costs mean that the estimated number may be plus or minus 10-20 percent from the actual DU. However, the field evaluation:

1. will point out obvious problems with the system hardware or management.
2. should provide further education to the grower on the correct way to operate the system.
3. is a rational, repeatable method. That is, even though the calculated DU may not be entirely accurate, relative increases in DU as a result of changes should show up with repeated evaluations using the same techniques.

Note also that there are many different ways that a system can be evaluated. An irrigation specialist may look at a farm from a holistic point of view and make observations and suggestions that speak to improving obvious deficiencies first. Then as the big changes are made, formal, numeric evaluations for DU (with their additional costs) would be made.

Any competent irrigation specialist can perform a DU evaluation. It doesn't have to be a formal Mobile Irrigation Laboratory. For example, the West Stanislaus Resource Conservation District will contract with a private consultant on an as-needed basis for system evaluations in their area. The software and explanations of the techniques (including on-site short courses) developed by ITRC are available from them for a nominal cost.

SECTION 3: MANAGING AN IRRIGATION EVENT

Each irrigation system type has its own set of operating characteristics. The irrigator must be aware of these characteristics in managing the individual irrigation event. The initial goal is to achieve good distribution uniformity (DU) – that is, water should soak evenly into the ground throughout the field. Then, the irrigator must be able to control the total amount of water applied.

Managing individual irrigations may be relatively easy, as with a pressurized system such as field sprinklers, center pivots, or a micro irrigation system. In these situations the operator basically turns the system on and off.

Managing flood-type irrigation systems such as furrow or border checks can involve a great deal of effort. With sprinkler and micro irrigation systems the rate of water infiltration into the soil is dependent on the system application rate. With flood systems water infiltration is dependent on the infiltration rate of the soil alone. This will change with time during the irrigation, sometimes very quickly (with clays and what is known as "cracking clays") and sometimes slowly (with sandier soils). The experience of the irrigator in adjusting the rate of water advance across a field and knowing when to terminate is critical to irrigation efficiencies with flood systems.

SECTION 4: IRRIGATION SCHEDULING

Irrigation scheduling is a generic term applied to any technique/practice that is intended to aid the grower in determining when and how much to irrigate. Although some authorities will categorize these techniques as either soil-based or plant-based, a more general terminology may be to divide them into two major families – **water budget** and **graphical.**

The science of irrigation scheduling is very well developed and in widespread use in one form or another. However, it is an exercise in information economics – that is, "How valuable is this information?" Irrigation scheduling can be practiced in a number of ways, some very expensive and complex, some very economical and simple. For example, a very simple level would be using a soil probe and taking periodic samples, feeling the sample for moisture, and making a determination of when and how much water to apply based on knowledge of the soil's holding capacity and the crop's normal rooting patterns. This would be a form of graphical or **bottom-line** scheduling. The most complex would be the use of automated soil moisture sensors sending data continuously to a central computer that inputs the data (along with data concerning irrigations, crop coefficients, daily weather, etc.) into a water budget equation.

Irrigation scheduling is always listed as an effective management practice that can improve field irrigation efficiency. However, it is emphasized that irrigation scheduling is simply an aid in knowing when and how much to irrigate. It says nothing about <u>how</u> to irrigate. For example, a scheduling system indicates a field requires 3.5 inches net application of water and that it should be applied next Tuesday. However, if the irrigator can't achieve a DU above 60 percent, or can't control the irrigation to apply a net 3.5 inches, or doesn't have the flexibility in the primary water supply that allows an irrigation on Tuesday (see Box B), then the information is of little value.

CIT developed a free irrigation scheduling program called WATERIGHT (**www.wateright.org**). The program is designed for three audiences: agriculture, commercial turf growers and homeowners. The WATERIGHT web site is a multi-functional, educational resource for irrigation water management.

Box B – Flexibility in the farm's water supply

Water supplies have many characteristics including total quantity available, quality, cost, and priority of the right to use the water supply. Another characteristic is flexibility. Ideally, the frequency, rate and duration of water supplies should be flexible. That is, the irrigator can access the water at will (frequency of use), can obtain varying flow rates (i.e., gallons per minute water flow), and can turn the flow on and off at will (duration of use). Improving the flexibility of water supplies is an important management practice for improving on-farm water efficiency.

In real life, various aspects of flexibility may be lacking in any water supply:

- With a water well (assumed to be owned by the irrigator) water can be turned on and off at will, but perhaps it does not provide the original flow rate (the pump may be worn or there might have been a systemic change in the water table due to drought or increased pumping by other irrigators). The pumping water level may be such that the water costs too much to use for a particular crop. Possibly the water quality is poor.
- An irrigation district may be able to provide water on 24-hour notice but may be restricted in the flow that can be delivered (due to the design of the canal system) and may require 24-hour use durations (i.e., the irrigator could have water for one day, two days, etc.).
- Some older districts may only deliver water on a set schedule (e.g., the irrigator has access to water every two weeks, whether the water is needed or not) – although this is currently rare in California.

As an example of the importance of water supply flexibility:

- Assume an irrigator is using an accurate irrigation scheduling system that predicts the crop needs water on Monday and the application should be 4.5 net inches. Note that the identification of water needed on Monday is generally related to crop development. However, in certain situations it may be that the irrigation system is very efficient in applying 4.5 net inches or there may be a labor constraint (e.g., a standard impact sprinkler system is being used and labor is only available to turn it on and off in 12-hour increments).
- Ideally then, the irrigator is able to turn the water on on Monday, obtain a flow rate necessary to run the irrigation system efficiently, and is able to turn it off after 4.5 net inches has been applied.
- Any obstacle to turning the water on on Monday, operating the system efficiently, and turning off the water at the right time may impact crop development and/or irrigation event efficiency.

Evapotranspiration (ET)

The **evapotranspiration (ET)** of a plant is the loss of water into the atmosphere by natural evaporation and transpiration. It is generally used to identify how much water plants need to be healthy and productive. There are many factors that can affect ET, these are: weather, air temperature, humidity, wind, soil type, plant type, and root depth. Estimating ET using equations is a common practice today. Due to the many factors affecting the ET outcome it is extremely difficult to formulate an equation that can accurately produce ET rates. Therefore, reference crop ET were developed by researchers. These rates are generally stated in inches or millimeters.

The reference crops used to determine ET are generally grass or alfalfa. These two crop types have been studied extensively and have good data. ET from grass surfaces are noted as ETo and where ET from alfalfa is noted as ETr.

Crop Coefficient (Kc)

Crop coefficient is usually denoted as Kc. Generally a Kc is a number between 0.1 and 1.2. This number is then multiplied by ETo to get the crop ETc. The ETc can be used to help growers determine how much water should be put onto the soil for the crops they have. ETc calculation example:

$$\begin{aligned} \text{ETo} &= 0.20 \\ \text{Kc} &= 0.45 \\ \text{Then, ETc} &= 0.20 \times 0.45 = 0.09 \text{ inches/day} \end{aligned}$$

This means that the plant is essentially using up to 0.09 inches of water per day so we need to put 0.09 inches per day back into the soil to maintain the water level in the soil and promote plant health.

Crop coefficients differ by crop, growth stage, and by cultural practices. For instance, peaches will have a different Kc requirement than almonds. A peach tree at an earlier stage (seedling) will have a different Kc requirement than a mature peach tree.

The University of California Cooperative Extension has prepared leaflets of different crop coefficients that can be found at http://biomet.ucdavis.edu/irrigation_scheduling/bis/BIS.htm. Another source where these crop coefficients can be found is www.wateright.org/references.asp.

SECTION 5: DIFFERENT TYPES OF IRRIGATION

Every irrigation system has a variety of advantages and disadvantages based on where and how it is adapted. Depending on the situation, one irrigation system may have inherent advantages over another.

Drip

Drip irrigation is the application of water through a drip hose. Drip places a slow rate of water application flow with higher frequency of events. In other words, drip delivers a small rate of flow but runs often during plant peak water demand. The distribution uniformity (DU) of drip on a well-designed and maintained irrigation system should be over 85 percent DUlq and can be as high as 95 percent DUlq. Unfortunately, many poorly-designed or maintained systems have a DUlq of less than 80 percent. The advantage of drip irrigation is on-demand water for each plant as soon as the system is turned on. Control of the irrigation event can be very precise, potentially leading to good water use efficiency. Almost any agricultural crop can be grown using drip, drip tape, or micro sprinklers.

Figure 8 – Drip emitter

Micro Sprinklers

Micro sprinklers and/or fan jets are a higher pressure drip irrigation system that spreads the water application over a wider area, allowing for good root spreading. The flow rate for each emitter is usually much higher than a conventional drip system. With good design and maintenance, the DUlq of micro sprinklers should exceed 80 percent. Micro sprinklers require higher pressure and flow to run than conventional drip, potentially increasing energy costs.

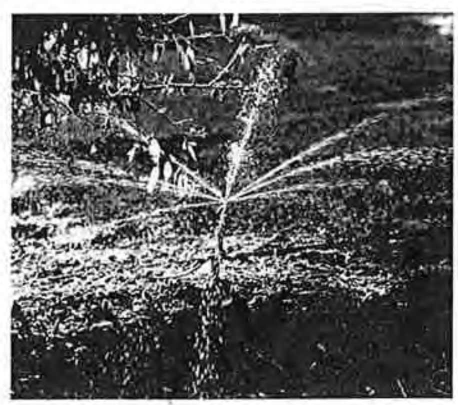


Figure 9 – Micro sprinkler

Sprinklers

Conventional sprinkler irrigation requires high pressure and flow for each nozzle. Distribution uniformity is usually somewhat lower than for drip or center pivot irrigation systems. Environmental factors such as wind and evaporation must be taken into consideration. A well-designed and maintained sprinkler irrigation system DUlq is 70 percent. An advantage for many sprinkler systems is that they can be moved from one target site to another, decreasing system cost and allowing greater flexibility for pre-plant water applications.

Figure 10 – Sprinklers

Flood or Furrow

Flood or furrow irrigation is the least expensive irrigation method from an equipment standpoint. Labor costs may be increased but flood allows good flexibility on level ground and can attain a DUlq up to 75 percent. A disadvantage is that you cannot irrigate effectively on ground that is not level. This is not "water on demand" like drip or sprinklers can be. Flood is considered a "low frequency" irrigation event system.

Figure 11 – Flood irrigation

Center Pivot

Center pivots are the number one installed pressurized irrigation system in the world. They allow for irrigation on hilly terrain or flat ground and properly designed and maintained can attain a DUlq of 85 percent and higher. It is not unusual for center pivot systems to last well over 30 years making them economical to install and maintain. Irrigation events can be precise with irrigation and water use efficiency very high because of good DU. A disadvantage of center pivots is they are unable to irrigate the corners of blocks, even with end guns so areas of the field are not irrigated. Even without irrigating the corners, pivots can be very efficient especially where a lack of water, not land, is an issue. Another disadvantage can be certain crops cannot be grown because of disease issues.

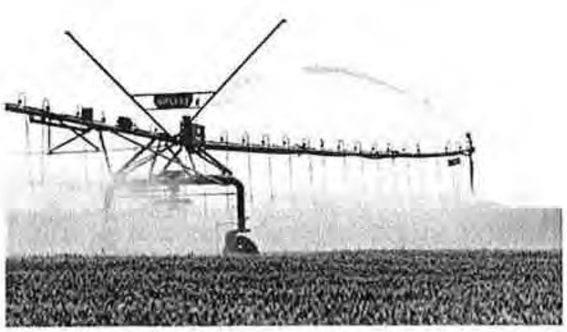


Figure 12 – Center pivot

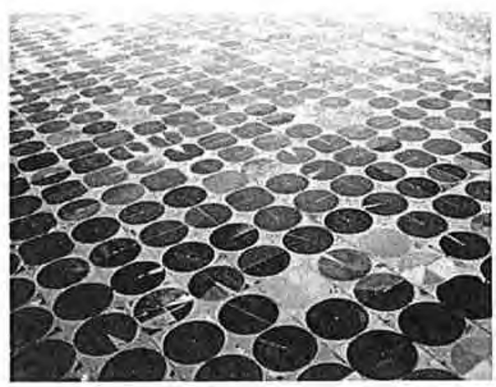


Figure 13 – Aerial view of center pivots

SECTION 6: IRRIGATION SYSTEM MAINTENANCE

Achieving high irrigation efficiency with an irrigation system that is in disrepair will be difficult if not impossible. Different irrigation system types have different maintenance requirements. The following are some of the more important aspects for system maintenance.

For **flood irrigation systems**, it is important to maintain:

- a smooth field surface graded to the appropriate slope.
- sufficient flow delivery capacity.
- sufficient drainage and/or tailwater return system capacity.

For **sprinkler systems**, it is important to ensure that:

- the correct nozzle size is used throughout a field (may include flow control).
- nozzles are not excessively worn or clogged.
- correct pressures are maintained during the irrigation.
- irrigation pipe leaks are repaired.

For **micro systems**, it is important to ensure that:

- the correct number and type of emission devices (may include pressure compensation) are used throughout the field.
- system pressures are correct.
- emission devices are not worn or clogged.
- irrigation system delivery pipes and hoses are repaired.

  Maintenance issues are critical with micro systems due to the large number of devices in the field and their relatively low individual flow rates. The low flow rates imply very small flow passages with an increased potential for clogging. Filtration and chemical additives are essential for keeping sediments, algae and/or precipitants from blocking emission devices.

SECTION 7: ENERGY AND IRRIGATION

The Water/Energy Nexus

The connection between energy and water has been widely documented and is especially important in California. The **water/energy nexus** affirms there is a correlation between delivering water for irrigation and energy. Energy is required to deliver water for agricultural irrigation purposes and systems. Because of this, greater emphasis has been placed on conserving both water and energy. The following examples illustrate that:

1. irrigating using less water can potentially save energy.
2. attaining higher efficiency with the irrigation system equipment and pumps can lead to water savings.

The relationship between energy and water in California is undeniable. A California Energy Commission (CEC) report in 2005 stated "water-related energy use consumes 19 percent of the state's electricity, 30 percent of its natural gas, and 88 billion gallons of diesel fuel every year." These figures can be debated, however, the fact that irrigation requires a tremendous amount of California's total energy use is not debatable.

There is an energy cost associated with delivering water for irrigation. The water/energy nexus can be demonstrated in the equation for electricity.

$$\textbf{kWh/year} = \textbf{kWh/AcFt} \times \textbf{AcFt/year}$$

Where:

kWh/ year = annual kilowatt hours of energy use

kWh/ AcFt = how many kilowatt hours are needed to pump an acre foot of water (about 325,851 gallons) through the irrigation system

AcFt/ year = how many acre feet pumped in a year

The equation basically means that the amount of total energy consumed per year to move irrigation water equals the energy per unit of water moved, in this case acre feet, multiplied by the total acre feet per year moved.

Let's insert some numbers into the equation to illustrate the point:

100,000 kWh/ year = 200 kWh per acre foot multiplied by 500 acre feet per year pumped.

Three Ways to Save Energy

There are three basic ways to decrease energy usage when pumping water.

1. Increase irrigation efficiency (IE or water use efficiency)
2. Decrease irrigation system pressure or total lift of the irrigation pump
3. Increase overall pump efficiency (OPE) of the irrigation pump

1. Increase irrigation or water use efficiency

All things being equal, increasing the IE (WUE) will result in pumping fewer acre feet and decreasing energy usage (assuming that enough water was being delivered previously). The following equation illustrates this point:

$$\textbf{AcFt/Year} = \frac{\textbf{Acres} \times (\textbf{ETc} - \textbf{EffRain})}{(1 - \textbf{LR}) \times \textbf{IrrEff}}$$

Where:

AcFt/ Year = total water pumped to the crop

Acres = the target irrigation area (in acres)

ETc = evapotranspiration crop coefficient (crop water requirement) in inches converted to feet

EffRain = effective rainfall supplying part of the crop water needs in inches converted to feet

1 – LR = allowance for extra applied water to leach salts below the root zone

IrrEff = irrigation efficiency

The equation indicates that in order to decrease the total acre feet per year delivered to the target crop, you have to take the crop target acres x the ETc (crop water use) minus any beneficial rain, divided by the required salt leaching (1 – LR) that is multiplied by the irrigation efficiency (IE).

The following examples illustrate the impact of increasing the irrigation efficiency from 80 percent to 90 percent.

INCREASE IE EXAMPLE 1	INCREASE IE EXAMPLE 2
Acres= (40) ETc- 48" or (4) ft EffRain= 12" or (1) ft (1 – LR)= (1 - .2) or .8 **IE= (.80) or 80%**	Acres= (40) ETc= 48" or (4) ft EffRain= 12" or (1) ft (1 – LR)= (1 - .2) or .8 **IE= (.90) or 90%**
AcFt/Year = $\frac{\text{(Acres 40) x (ETc 4 ft - EffRain 1 ft)}}{\text{(1 - LR= .2) x } \textbf{(IE .80)}}$ AcFt/ Year = $\frac{(40) \times (3)}{(.8) \times \mathbf{(.80)}}$ **AcFt/Year = 187.5**	AcFt/Year = $\frac{\text{(Acres 40) x (ETc 4 ft - EffRain 1 ft)}}{\text{(1 - LR= .2) x } \textbf{(IE .90)}}$ AcFt/ Year = $\frac{(40) \times (3)}{(.8) \times \mathbf{(.90)}}$ **AcFt/Year = 166.67**

All things being equal, increasing the irrigation efficiency decreased the total acre feet of water required (better water use efficiency) to grow the crop. Since the pump will not have to run as long to pump water – 166.67 AcFt in Example 2 versus 187.5 AcFt in Example 1 – this saves energy.

This was accomplished by raising the irrigation efficiency. The best way to increase the IE is to increase the distribution uniformity of the irrigation system. Good uniformity allows for even distribution and application of water to the target area, potentially resulting in increased IE. This could be accomplished by better system design, maintenance, and supplying the correct flow and pressure to the irrigation system components.

2. Decrease irrigation system pressure or total lift of the pump

All things being equal, decreasing irrigation system pressure or the total lift of the irrigation pump will save energy. The following equation illustrates this point:

$$\textbf{kWh/AcFt} = \frac{\textbf{1.024} \times \textbf{TotlDynHead}}{\textbf{OverallPumpEfficiency}}$$

Where:

1.024 = constant

TotalDynamicHead (TDH) = total pressure and lift developed by the pumping system (lift plus discharge pressure X 2.31)

OverallPumpEfficiency (OPE) = overall pumping efficiency (how efficient is the pumping plant itself using energy to move water)

Total dynamic head (TDH) or **total lift** of the irrigation pump includes the distance or lift from the water source plus any friction losses (pressure losses) through the system plus the pressure to properly meet design requirements of the irrigation system (Figure 14). TDH is usually measured in feet with 2.31 feet equal 1 psi of pressure (Figure 15).

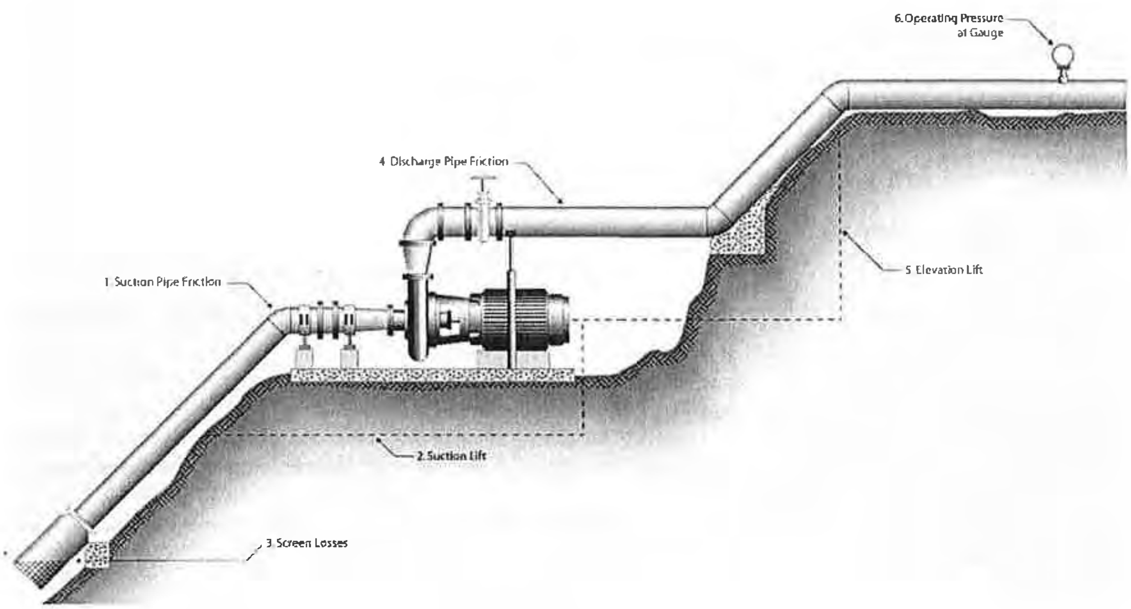


Figure 14 – A stable operating condition showing the total pump lift and potential friction losses

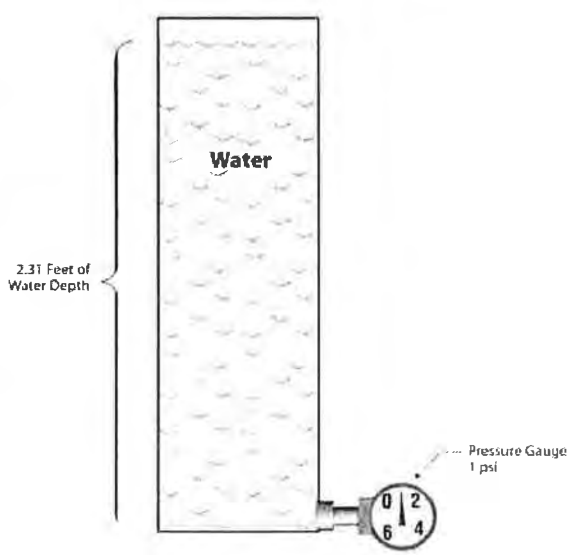


Figure 15 – TDH is usually measured in feet with 2.31 feet equal 1 psi of pressure

An example of total lift of the pump including pressure losses.

1. Lift from the pumping water level (PWL) to the surface = 200 ft
2. 10 psi of pressure (head) loss through the pipes, valves, etc.

   10 psi x 2.31 (convert to ft) = 23.1 feet (round to 23 ft)
3. 30 psi of pressure to run drip irrigation system (design requirement)

   30 psi x 2.31 (convert to ft) = 69.3 feet (round to 69 ft)

Add these together

200 ft from PWL + 23 ft friction loss + 69 ft drip system design requirement example =

292 ft TDH or total lift of the pump

Find a way to decrease the TDH by decreasing the PWL (i.e. well rehabilitation to clean perforations and raise PWL), decreasing friction losses (i.e. larger pipe, less friction), or decreasing system pressure by converting from a higher pressure irrigation system to a lower pressure irrigation system (i.e. fanjets to double line drip that runs at a lower pressure). All these would save energy by lowering the TDH.

DECREASE TDH EXAMPLE 1	DECREASE TDH EXAMPLE 2
Constant- 1.024 **TDH- 292 feet** OPE= 65% or .65	Constant- 1.024 **TDH- 251 feet** OPE= 65% or .65
kWh/ AcFt = $\frac{1.024 \text{ X } \mathbf{292}}{.65}$ **kWH/ AcFt = 460.01 or rounded to 460**	kWh/ AcFt = $\frac{1.024 \text{ X } \mathbf{251}}{.65}$ **kWH/ AcFt = 395.4 or rounded to 395**

All things being equal, decreasing the TDH will lower the energy cost to move water. Example 1 required 460 kWh to move the same volume of water as Example 2 that only required 395 kWh. An example of potential savings to pump an acre-foot of water during off-peak hours (in California is approximately $.13/ kWh) would be:

Example 1: 460 kWh X $.13/ kWh = $59.80 per AcFt

Example 2: 395 kWh X $.13/ kWh = $51.35 per AcFt

3. <u>Increase the overall pump efficiency - OPE</u>

All things being equal, increasing the overall pump efficiency or OPE of the irrigation pump will save energy. The following equation illustrates this point:

$$\textbf{kWh/AcFt} = \frac{\textbf{1.024} \times \textbf{TotlDynHead}}{\textbf{OverallPumpEfficiency}}$$

Where:

1.024 = constant

TotalDynamicHead (TDH) = total pressure and lift developed by the pumping system (lift plus discharge pressure X 2.31)

OverallPumpEfficiency (OPE) = overall pumping efficiency (how efficient is the pumping plant itself using energy to move water)

Overall pump efficiency or OPE is a measurement of the ENERGY IN from the power source (electricity- sometimes referred to as "wire to water," natural gas, diesel, etc.) versus the ENERGY OUT from the pump inflow and pressure expressed as TDH developed by the pump. Increasing OPE means using less energy to develop that flow and pressure, saving energy. So if installing a more efficient pump increases the OPE from 55 percent to 65 percent, energy will be saved.

INCREASE OPE EXAMPLE 1	INCREASE OPE EXAMPLE 2
Constant- 1.024 TDH- 292 feet **OPE= 55% or .55**	Constant- 1.024 TDH- 292 feet **OPE= 65% or .65**
kWh/ AcFt = $\frac{1.024 \text{ X } 292}{\textbf{.55}}$ **kWH/ AcFt = 543.7 or rounded to 544**	kWh/ AcFt = $\frac{1.024 \text{ X } 292}{\textbf{.65}}$ **kWH/ AcFt = 460.01 or rounded to 460**

All things being equal, increasing the OPE will lower the energy cost to move water. An example of potential savings to pump an acre foot during off-peak hours (in California is approximately $.13/ kWh) would be:

Example 1: 544 kWh X $.13/ kWh = $70.72 per AcFt

Example 2: 460 kWh X $.13/ kWh = $59.80 per AcFt

Off-Peak vs. On-Peak Energy Cost to Move Water – Time-of-Use Rates

All agricultural electrical utility customers in California are being transitioned to **smart meters** for ag use rates. This will vary the cost by the time, the day, and the season. Many agricultural customers have taken advantage of these rates for years to save money but now all customers are required to be on **time-of-use (TOU)** rates. For pressurized irrigation systems such as drip, fan jets, drip tape, micro sprinklers, center pivot, and high pressure sprinklers the ability to pump off-peak will only be possible with some management changes. Irrigation system timers to automatically shut off the irrigation event during on-peak time may be feasible, but for flood irrigation and some sprinkler applications, this might prove difficult (the irrigation event can't be shut off in the middle of the set). Changing the "culture" of when to irrigate has been accomplished by many managers but does require a different "mindset" and the ability to schedule labor and operations differently than before. Still, even small changes can result in major savings for electrical energy costs.

There are various Ag TOU rates for irrigation pumps but the cost per kWh can be substantial. Basically, comparing on-peak vs. off-peak looks like this:

On-peak – Monday through Friday, 12 noon to 6 pm from May 1st to Oct 31st

Off-peak – Monday through Friday, 6 pm to 12 noon the following day including the entire weekend from 6 pm Friday evening until Monday morning at 12 noon.

There is a total of 168 hours in a week (7 days X 24 hours)

On-peak TOU rates – Five days a week during the late spring to fall for six hours a day or a total of 30 hours. Prices for rates can double or triple during this peak time. For example Ag4C pump rates are approximately $.32/ kWh during peak time of use.

Off-peak TOU rates – The remaining 138 hours in the week. Prices for rates may be as low as $.12/ kWh.

When a grower can run the pump during off-peak hours (potentially up to 138 hours/week), they can save substantial money versus operating the pump during on-peak hours (potentially up to 30 hours/week). Most pressurized irrigation system managers recognize this and try to irrigate off-peak. Some **partial-peak** hours may apply for certain rate schedules.

There are many different rate schedules for different utilities so the grower should periodically check with their electric utility provider to access current rates and determine the most advantageous schedule to meet their needs.

Additional Ways to Save Energy

One of the ways growers can save energy pumping water is by getting a **pump efficiency test** or an audit of the irrigation pump. This baseline measurement can assist growers making management decisions in improving pump performance to save energy. Every pressurized irrigation system design has a required flow and pressure to deliver good distribution uniformity (DU). The pump output should meet system design requirements so that good DU is the result. Testing the irrigation pump tells the grower how well the pump matches the irrigation design. It also indicates the overall pump efficiency (wire-to-water) of the pumping plant. A pump test can indicate how improvements to the irrigation pump can correct flow and pressure and deliver water efficiently. California utilities such as PG&E offer subsidized pump efficiency tests with an analysis of the pumping plant. Additionally, incentives to repair inefficient pumps are available.

Another method of saving energy during an irrigation event is to examine or audit the irrigation system. Improvements to system performance can increase the DU, leading to potential energy and water savings through the system. The grower should look at the entire irrigation system, from pump to emitters to determine if improvements might lead to energy and water savings.

SECTION 8: HELPFUL INFORMATION

Acronyms

AcFt	acre-foot (1 AcFt/ac = 1-ft depth of water) = 325,853 gallons
AcFt/yr	acre-foot/year
AC	acres
DU	distribution uniformity
DUlq	distribution uniformity of the lower quarter
IE	irrigation efficiency
OPE	overall pump efficiency
PWL	pumping water level
SJV	San Joaquin Valley
TDH	total dynamic head
TOU	time-of-use

Online Education Resources

Advanced Pumping Efficiency Program (APEP) – www.pumpefficiency.org

California Department of Food and Agriculture (CDFA) – http://www.cdfa.ca.gov/

California Natural Resource Conservation Services – http://www.ca.nrcs.usda.gov/

Center for Irrigation Technology – www.californiawater.org

CIMIS (CA Irrigation Mgmt Information System) – http://wwwcimis.water.ca.gov/cimis/welcome.jsp

University of California Cooperative Extension Biometeorology Group – http://biomet.ucdavis.edu

USDA – http://www.usda.gov/wps/portal/usda/usdahome

Wateright –www.wateright.org

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This project, Water Use Efficiency for the San Joaquin Valley Specialty Program, was funded by a grant from the California Department of Food and Agriculture.

FREE!

BUY FRESH BUY LOCAL

2014 Local Food Guide

SANTA CLARA VALLEY REGION, 1ST EDITION

SANTA CLARA
SAN BENITO

CSAs
FARMS
FARM STANDS
ORGANIZATIONS
FARMERS MARKETS
FOOD ARTISANS
RESTAURANTS & GROCERS

A publication of Community Alliance with Family Farmers

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ABOUT THIS GUIDE

Community Alliance with Family Farmers (CAFF) is proud to present the first edition of the Buy Fresh Buy Local Santa Clara Valley Local Food Guide. This guide is designed to be a useful tool in identifying the local, fresh, and delicious food of the Santa Clara Valley. The guide was developed by CAFF in an effort to highlight the bounty of our local farmers and raise awareness about the importance of buying local food. Throughout this member-based guide, you will find valuable information to help advance your commitment to eating fresh, local foods, such as:

- A Santa Clara Valley seasonality chart highlighting the diverse fruit and vegetable crops that are produced throughout the year in this region
- The schedule and location information on nearly 40 farmers markets that operate weekly or seasonally throughout the valley
- A list of Community-Supported Agriculture (CSA) programs
- Editorials about the history of farming in the "Valley of the Heart's Delight", the farm to table movement, and urban agriculture and educational farms
- A list of organizations within the Santa Clara Valley that support the environment and a sustainable food system

Hungry for more? All the information in this guide, and more – including listings for other regions of California – is available at: www.caff.org

A note about this 2014 edition:
While we understand that this is not an exhaustive guide for our region, we've made every effort to recognize businesses that support Buy Fresh Buy Local. The Buy Fresh Buy Local campaign in Santa Clara Valley is ongoing, and this guide should serve as a snapshot of current members at time of publication. If you are interested in joining the Buy Fresh Buy Local campaign, see the membership form on the inside back cover of this guide and become a CAFF member!

Community Alliance with Family Farmers

Food for your family, Tools for the farmer, Voice for the farmer

The Community Alliance with Family Farmers (CAFF) advocates for Californian family farmers and sustainable agriculture.

Over 90% of California's farms and ranches are family-owned; however, many struggle to stay in business. To help resolve this issue, CAFF works directly with our communities and regional members, particularly our family farmers, to increase the use and consumption of fresh, healthy, local food, and to help growers prosper. Our goal is to strengthen family farms, which are the cornerstone of healthy and economically viable communities.

This guide is a project of CAFF's Buy Fresh Buy Local program, which creates new opportunities for family farmers by educating consumers and food businesses about the benefits of buying locally. CAFF programs areas include Biological Agriculture, Farm to School/Hospital, Farm to Market Tools and Services, and Policy.

For more information about CAFF's programs, please visit: www.caff.org

CAFF Santa Clara Valley
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Gilroy, CA 95020
(408) 337-5644

Food Routes Network

The California Buy Fresh Buy Local program is a project of CAFF in collaboration with the national organization, the Food Routes Network.

www.foodroutes.org

For more information, please visit: www.foodroutes.org

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SPECIAL THANKS TO:
Our Regional Manager, Sadie Clements, for all of her hard work on the Buy Fresh Buy Local campaign in the Santa Clara Valley.

All of the amazing organizations on pg. 30 for their support and dedicated work in the Santa Clara Valley and beyond.

The Buy Fresh Buy Local campaign was made possible with support from the Clarence E. Heller Charitable Foundation and the California Department of Food and Agriculture through a 2012 Specialty Crop Block Grant. We are additionally grateful to the businesses that advertised in the guide. We encourage you to support these businesses that buy and sell local food!

Reboot the Fruit!

A Letter from CAFF - Santa Clara Valley Region

A fertile region situated between the Santa Cruz Mountains and the Diablo Range, the Santa Clara Valley was once called the "Valley of Heart's Delight" for its abundance of blossoms from stone fruit orchards and its role as the largest fruit canning and dried fruit packing center in the world. After the second World War, the economy shifted from agriculture to manufacturing, and prime ag land was converted to subdivisions to accommodate the growth in residents. The population skyrocketed from around 200,000 in 1945 to 1.5 million in the 1980's and 1990's as the tech industries moved in; meanwhile, land for specialty crop production decreased from 100,000 acres to just 15,000 acres of fruits, vegetables, and nuts. The agriculture sector remains significant, with over $260 million in gross sales in 2012. But farmers are facing development pressures, drought, and labor shortages, and they need our support to ensure that farming remains viable in the region to preserve green space, support our local economy, and reduce the miles our food travels to get to our plates.

At the same time, 21% of the county's children live in households that are food insecure, over half the residents are overweight (38%) or obese (17%), and 80% reported that they do not eat at least 5 servings of fruits and vegetables a day. Perhaps this has something to do with the fact that there are 4 times as many convenience stores and fast food restaurants as full service supermarkets and other produce vendors in the county. You can find out more about the regional landscape in the Santa Clara County Food System Alliance's "Santa Clara Food System Assessment" at **www.aginnovations.org/alliances/santaclara.**

When we opened the Santa Clara Valley office in 2009, CAFF was operating out of a small trailer in Sunnyvale, working primarily with Moreland School District to educate students on farm field trips about healthy, farm-fresh food. Six years later, we are now working with 7 school districts to educate students in the classroom and provide access to fresh food in their cafeterias. CAFF launched the Buy Fresh Buy Local campaign in 2012 to reach the larger community by bridging the healthy food access movement in urban areas with the fight to preserve agricultural viability in south county. 75 farmers, businesses, nonprofit organizations, and individuals have joined the campaign to build and promote a local food system that

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benefits all. This means we are helping farmers develop food safety plans, connecting restaurants and retailers to local growers, supporting schools in overcoming barriers to purchasing local produce, making it easier for consumers to identify local products in as many outlets as possible, and much more. Joining other cities and counties across the nation, Santa Clara County is officially proclaiming September "Local Food Month" to celebrate the rich bounty of the region through events, workshops, and volunteer days open to the public. With your help we can grow this movement to support the remaining farmers in the region and feed our community with healthy, fresh food. Join us as we "Reboot the Fruit!" and celebrate the Valley of Heart's Delight again.

Warmly,

Sadie Clements, RD
Santa Clara Valley
Regional Manager

Diana Abellera
Statewide Food
Systems Director

Family Farming in Santa Clara Valley

by Andy Mariani

I am the owner of Andy's Orchard located in Morgan Hill. It's a family farm founded by my immigrant parents who arrived from Europe in the 1930s. My father, a long-time vineyardist, recognized that the Valley of Heart's Delight was a perfect place for growing fruit crops.

Originally, we grew tree-ripened apricots and prunes for drying. There was a built-in incentive to harvest only the ripest fruit since higher sugar content meant greater yield of dried product. Growing fruit with high sugar content and nutritive value is an old concept but recently re-invented in what is now termed high brix farming. My parents also grew their crops with mostly organic and sustainable practices. It was really the only way they knew how to farm.

Today, our farming methods haven't changed much, especially in terms of how we grow our fruit. We've added many more rare and heirloom varieties, based only on one criterion: eating quality. These varieties are not the kind that are mass-produced and found in supermarkets. As a youth, I ate only ripe fruit full of flavor. Now it would be called artisanal fruit; growing it is sometimes risky and the margins are often slim, but I think we excel at our craft. Our tree-ripened cherries, apricots, peaches, nectarines, and plums have gained national

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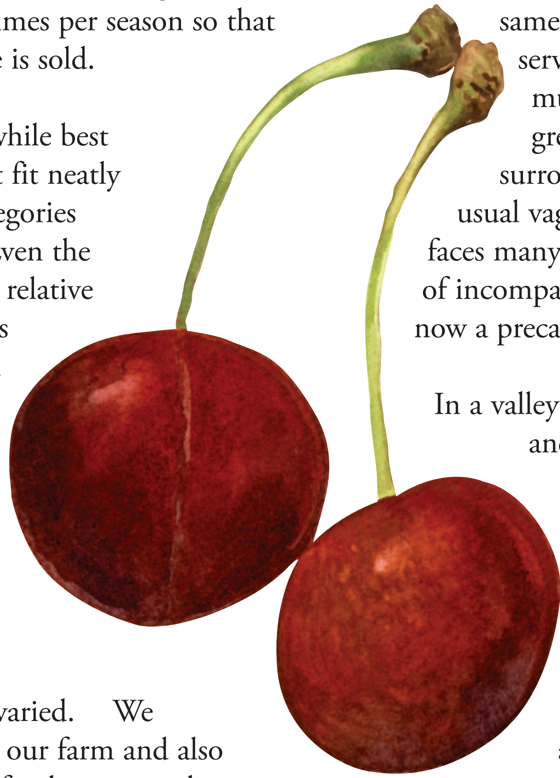
recognitions for their quality. With of the help of local fruit expert volunteers, we've even created some of our own exclusively grown varieties, with superior flavor in mind.

The handling of such fruit can be highly inefficient and intensely laborious. The fruit is harvested in special containers, handled and packed by hand, and never subjected to mechanical packing lines, fungicidal dips, waxing or de-fuzzing. Highly trained employees do most of the work, and any given variety may be harvested up to six times per season so that only fruit picked at its prime is sold.



Our methods of farming, while best described as artisanal, do not fit neatly into any of the common categories like organic or sustainable. Even the descriptor "tree-ripened" is a relative term and has lost much of its original meaning. The truth of the matter is that fine fruit speaks for itself. We practice an integrated approach relying on a minimum use of pesticides and adhere to a rigorous food safety program.

The markets we sell to are varied. We have a fruit stand located on our farm and also sell to specialty markets and food stores, and restaurants in the Bay Area, including some high-tech giants in Silicon Valley. This is the first summer that we'll have a vendor spot at the Santa Monica Farmer's Market in southern California. Andy's also sells fruit by mail order---a subscription program that provides overnight delivery of tree-ripened fruit to the customer's doorstep. We continue to dry some fruit and contract with others to utilize our fruit in preserves, confections, and baked goods.

Visitors are able to attend agritourism events like fruit-tastings, educational tours, and harvest walks. These events allow visitors to come to our farm and learn more about what we do---an earnest attempt to connect with our urban neighbors who wish to learn about where their food comes from or perhaps wish to reconnect with their own rural past.

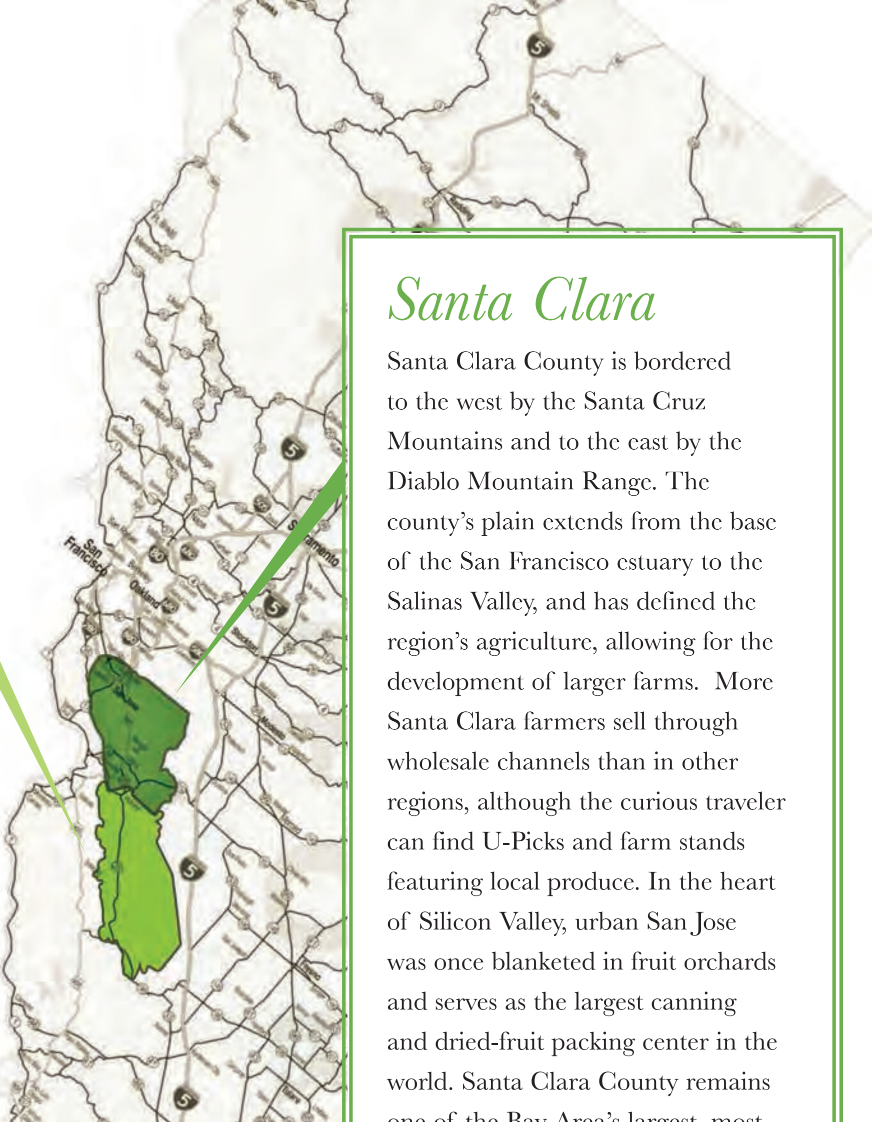
As the community around us becomes more urbanized, we enjoy a greater customer following, but there are also challenges. Since we settled in our present location, many nearby farms have vanished. The family farm was once a way of life; now the same land is covered with homes that serve as a bedroom community for a much larger urban one. As part of greater Silicon Valley, our orchard is surrounded by urban uses. Besides the usual vagaries of weather, local agriculture faces many difficulties including the proximity of incompatible uses, higher costs of inputs, and now a precarious water supply.

In a valley where 200,000 acres of orchards and vineyards once flourished, there are only a handful of family farms left. In the past, farmers loaded their fruit on a truck and sent it to market with the hope of some return for their hard work. Now they must be creative in terms of what is grown, farming practices, and marketing.

The American tradition of cheap, mass-produced food - generic and bar-coded - is thankfully eroding. Newer trends like "Farm-to-Table" and "Locavore", Slow Food, and heirloom preservation have helped heighten public awareness and appreciation for quality food. I feel fortunate that I now live in an era that allows me to continue farming the way my parents did, to continue a long family tradition, and also be recognized and rewarded for my efforts.

San Benito

From the Gabilan Mountains to the west to the Diablo range in the east, San Benito County includes an amazing supply of California's geography. Sandwiched between the layer of fog found along the coast and San Joaquin Valley's considerable heat, the county has a pleasant and moderate climate that boasts 333 sunny days annually! This unique weather, along with the fertile soil and adequate water supply, provides a perfect setting for San Benito County's largest industry: agriculture. The great majority of farms and ranches in the county are family-operated; 80% of farmers reside on their farms. Leaf lettuce, tomatoes, spinach and bell peppers, garlic, onions, broccoli, celery and cauliflower thrive especially well in this region. Also look for local grass-fed beef, olive oil, and renowned, delicious dried apricots.



Santa Clara

Santa Clara County is bordered to the west by the Santa Cruz Mountains and to the east by the Diablo Mountain Range. The county's plain extends from the base of the San Francisco estuary to the Salinas Valley, and has defined the region's agriculture, allowing for the development of larger farms. More Santa Clara farmers sell through wholesale channels than in other regions, although the curious traveler can find U-Picks and farm stands featuring local produce. In the heart of Silicon Valley, urban San Jose was once blanketed in fruit orchards and serves as the largest canning and dried-fruit packing center in the world. Santa Clara County remains one of the Bay Area's largest, most productive agricultural regions, with a remarkable array of fruit, vegetable, nut, and mushroom crops.

Santa Clara Valley Farmers Markets Benefit Local Growers and Consumers

by Zea Luce

One of the best ways to interact directly with local growers is at a local certified farmers market. Shoppers are able to experience the bounty of the region, learn where their food was grown, how it was grown, and who grew it. Farmers are able to sell their freshly harvested product directly to consumers, with no middleman.

In order to sell at a certified farmers market, the County Agricultural Commissioner must visit the farm to verify that growers are selling only the products that they grow themselves. Markets are regulated to ensure producers aren't buying and re-selling agricultural products; thus the quality and integrity of these farmers markets is upheld.

Farmers markets are plentiful in the Santa Clara Valley. They feature seasonal farm-fresh fruits and vegetables, Asian specialty produce, eggs, meat, dairy, nuts, flowers, vegetable starts, artisanal bakery goods, prepared foods, and live music. They are fun, bustling venues that are family friendly.

When asked what he liked best about managing farmers markets in the county, Doug Hayden, president of the California Farmers Market Association replied, "We provide an easy way to make healthy choices with the variety these farmers bring fresh to the market each week. When you interact with farmers you learn about their specialty crops. It's wonderful to be able to build a relationship with the farmers who grow your food."

When asked for tips for market shoppers, Hayden added, "Farmers market shoppers should be adventurous, taste new tree-ripened fruit and vine-ripened vegetables to find your favorites. Learn new recipes from the farmers. By buying direct from the growers and producers, shoppers can support local family farms."

"It's wonderful to be able to build a relationship with the farmers who grow your food."

FARMERS MARKETS

DAY	COUNTY	MARKET	TIME	SEASON	ADDRESS	CITY	CONTACT	WIC/EBT?
WED	San Benito	Downtown Hollister	3pm-7:30pm	May-Sep	San Benito St. btwn Fourth and Seventh Streets	Hollister	http://www.downtownhollister.org/farmersmarket.php	EBT/WIC
WED	Santa Clara	VA Palo Alto	10am-2pm	Apr-Nov	3801 Miranda Ave	Palo Alto	http://www.pcfma.com	EBT
WED	Santa Clara	Cambrian Park	4pm-8pm	May-Sep	Camden Ave & Union Ave.	San Jose	http://www.urbanvillageonline.com	WIC
WED	Santa Clara	Evergreen	9am-1pm	y/r	Evergreen Village Square, Ruby Ave. at Classico Ave.	San Jose	http://www.pcfma.com	EBT
WED	Santa Clara	Santa Clara Valley Medical Center	10am-2pm	May-Nov	751 S Bascom Ave	San Jose	http://www.pcfma.com	EBT
WED	Santa Clara	East Santa Clara Street	4pm-8pm	May-Oct	North 14th St. at East Santa Clara Street	Santa Clara	http://www.pcfma.com	EBT
WED	Santa Clara	Saratoga Village	2:30pm-6:30pm	y/r	Blaney Plaza, Big Basin Way and Saratoga Avenue.	Saratoga	http://www.saratogachamber.org/marketplace.php	
THUR	Santa Clara	Los Altos	4pm-8pm	May-Sep	State St & 2nd St	Los Altos	www.cafarmersmkts.com	EBT
THUR	Santa Clara	Morgan Hill	3pm-7pm	y/r	3rd Ave & Monterey Rd.	Morgan Hill	http://www.westcoastfarmersmarkets.org	WIC
FRI	Santa Clara	Vallco	9am-1pm	y/r	Vallco Shopping Mall, Stevens Creek and Wolfe Road	Cupertino	http://www.pcfma.com	EBT
FRI	Santa Clara	Mountain View	10am-2pm	y/r	El Camino Hospital, 2500 Grant Rd.	Mountain View	http://www.westcoastfarmersmarkets.org	WIC
FRI	Santa Clara	Palo Alto	1pm-6pm	y/r	Palo Alto Jewish Community Center, 3921 Fabian Way	Palo Alto	http://www.westcoastfarmersmarkets.org	WIC
FRI	Santa Clara	Kaiser Permanente San Jose	10am-2pm	y/r	270 International Circle	San Jose	http://www.pcfma.com	EBT
FRI	Santa Clara	San Jose Downtown	10am-2pm	May-Nov	San Pedro Square between Santa Clara St & John Street	San Jose	http://www.pcfma.com	EBT
FRI	Santa Clara	Kaiser Permanente Santa Clara	8:30am-1:30pm	y/r	Kaiser Permanente Medical Center, 710 Lawrence Expressway	Santa Clara	http://www.pcfma.com	EBT
SAT	Santa Clara	Gilroy	9am-1pm	May-Nov	7351 Rosanna Street & 7th Street	Gilroy	www.cafarmersmkts.com	EBT
SAT	Santa Clara	Morgan Hill	9am-1pm	y/r	3rd Street & Depot Street	Morgan Hill	www.cafarmersmkts.com	EBT
SAT	Santa Clara	Downtown Palo Alto	8am-12pm	May-Dec	Gilman St & Hamilton Ave	Palo Alto	http://www.pafarmersmarket.org	
SAT	Santa Clara	Berryessa	9am-1pm	y/r	1376 Piedmont Road	San Jose	http://www.pcfma.com	EBT
SAT	Santa Clara	Blossom Hill	9am-1:30pm	y/r	525 Blossom Hill Road	San Jose	www.cafarmersmkts.com	EBT
SAT	Santa Clara	Santa Teresa	10am-2pm	y/r	Kaiser Permanente San Jose, Santa Teresa Blvd. at Camino Verde	San Jose	http://www.pcfma.com	EBT

FARMERS MARKETS

DAY	COUNTY	MARKET	TIME	SEASON	ADDRESS	CITY	CONTACT	WIC/EBT?
SAT	Santa Clara	Santa Teresa	10am-2pm	y/r	Kaiser Permanente San Jose, Santa Teresa Blvd. at Camino Verde	San Jose	http://www.pcfma.com	EBT
SAT	Santa Clara	Willow Glen	9:30am-1:30pm	May-Nov	Lincoln Ave & The Garden Theater	San Jose	http://www.southbayfarmersmarkets.com	EBT
SAT	Santa Clara	Santa Clara	9am-1pm	y/r	Jackson Street at Homestead Rd	Santa Clara	http://www.urbanvillageonline.com	WIC
SAT	Santa Clara	Saratoga Farmers' Market at West Valley College	9am-1pm	y/r	14000 Fruitvale Ave	Saratoga	www.cafarmersmkts.com	EBT
SAT	Santa Clara	Sunnyvale	9am-1pm	y/r	Murphy Avenue at Washington	Sunnyvale	http://www.urbanvillageonline.com	WIC/EBT
SUN	Santa Clara	Campbell	9am-1pm	y/r	Campbell Ave at Central Ave	Campbell	http://www.urbanvillageonline.com	WIC
SUN	Santa Clara	Cupertino	9am-1pm	y/r	Cupertino Oaks Shopping Center, 21275 Stevens Creek Blvd	Cupertino	http://www.westcoastfarmersmarkets.org	WIC
SUN	Santa Clara	Los Gatos	8am-1pm	y/r	Santa Cruz Ave & Main Street	Los Gatos	http://www.southbayfarmersmarkets.com	EBT
SUN	Santa Clara	Milpitas Farmers' Market at the India Community Center	8am-1pm	y/r	525 Los Coches St.	Milpitas	http://www.pcfma.com	EBT
SUN	Santa Clara	Mountain View	9am-1pm	y/r	600 W Evelyn Ave	Mountain View	www.cafarmersmkts.com	EBT
SUN	Santa Clara	California Avenue Farmers' Market, Palo Alto	9am-1pm	y/r	California Ave at El Camino	Palo Alto	http://www.urbanvillageonline.com	WIC
SUN	Santa Clara	Alum Rock Village	8am-1pm	y/r	57 N White Rd	San Jose	http://www.pcfma.com	EBT
SUN	Santa Clara	Blossom Hill	9am-1:30pm	y/r	Ohlone-Chynoweth VTA Station, Santa Teresa Blvd and Hwy 87	San Jose	www.cafarmersmkts.com	EBT
SUN	Santa Clara	Evergreen	9am-1pm	y/r	Evergreen Village Square, Ruby Ave. at Classico Ave.	San Jose	http://www.pcfma.com	EBT
SUN	Santa Clara	San Jose Japantown	8:30am-12pm	y/r	Jackson Street btwn Sixth and Seventh Streets	San Jose	http://www.japantownsanjose.org	WIC

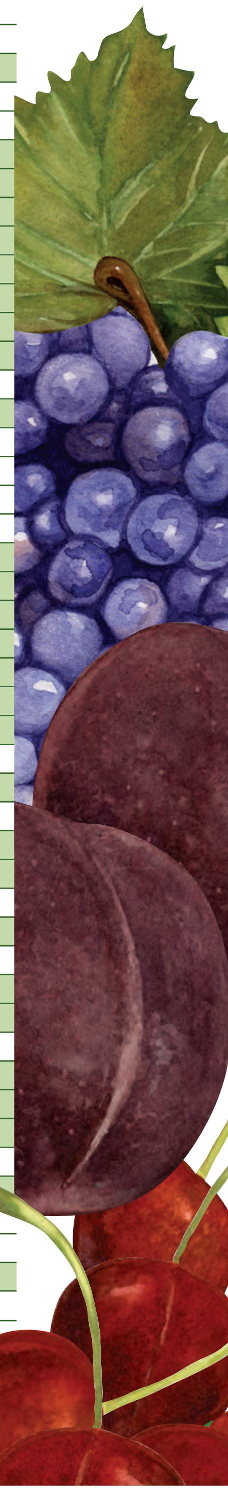
WIC is the Special Supplemental Nutrition Program for Women, Infants, and Children; a program of the USDA for low-income pregnant women, breastfeeding women, and infants and children under the age of five. **WIC** is commonly accepted directly by the farmer, although not all farmers will accept this type of payment.

EBT cards are distributed by Supplemental Nutrition Assistance Program (SNAP) and can be used at point of sale locations such as the markets listed above.

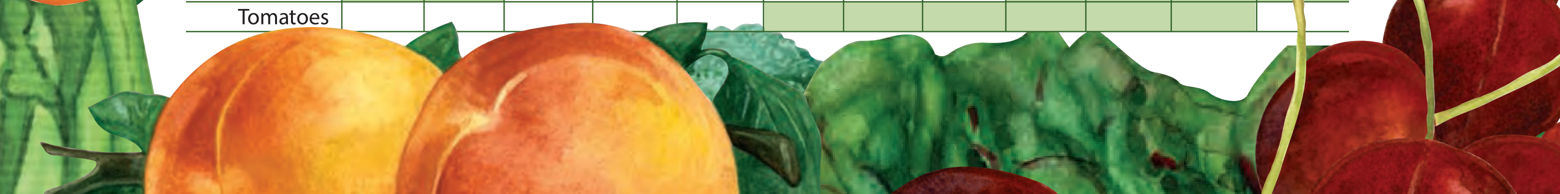
NOTES: Farmers Markets times and locations sometimes vary due to seasonality, winter hours, and other changes to the availabiltiy of their spaces. Please check with market management to confirm time and location.

Certified Farmers Market (**CFM**) - All markets listed here are Certified Farmers Markets, meaning only California grown agricultural products may be sold in the market, and all such agricultural products must be grown by the farmer selling them. Each farmer must be inspected and obtain a Producer's Certificate before they can sell at a Certified Farmers Market.

SANTA CLARA VALLEY SEASONALITY



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Apples	●	●	●					●	●	●	●	●
Apricots					●	●	●					
Artichokes			●	●	●	●			●	●	●	●
Arugula		●	●	●	●	●	●	●	●	●	●	
Asparagus		●	●	●	●	●						
Avocados				●	●	●	●	●	●	●		
Basil					●	●	●	●	●	●		
Beets	●	●	●	●	●	●	●	●	●	●	●	●
Blackberries					●	●	●	●	●			
Blueberries					●	●	●					
Bok Choy	●	●	●	●	●	●	●	●	●	●	●	●
Broccoli	●	●	●	●	●	●	●	●	●	●	●	●
Brussel Sprouts	●	●	●						●	●	●	●
Cabbage	●	●	●	●	●	●	●	●	●	●	●	●
Carrots	●	●	●	●	●	●	●	●	●	●	●	●
Cauliflower	●	●	●	●	●	●	●	●	●	●	●	●
Celery				●	●	●	●	●	●	●	●	●
Chard	●	●	●	●	●	●	●	●	●	●	●	●
Cherries					●	●						
Collards	●	●	●	●	●	●	●	●	●	●	●	●
Corn						●	●	●	●	●	●	
Cucumber						●	●	●	●	●	●	
Eggplant						●	●	●	●	●		
Figs						●	●	●	●	●	●	
Garlic	●	●	●	●	●	●	●	●	●	●	●	●
Grapefuit	●	●	●	●					●	●	●	●
Grapes							●	●	●	●	●	●
Kale	●	●	●	●	●	●	●	●	●	●	●	●
Leeks	●	●	●	●	●	●	●	●	●	●	●	●
Lemons	●	●	●	●	●					●	●	●
Lettuces	●	●	●	●	●	●	●	●	●	●	●	●
Melons						●	●	●	●	●		
Mushrooms	●	●	●	●	●	●	●	●	●	●	●	●
Nectarines					●	●	●	●	●			
Onions	●	●	●	●	●	●	●	●	●	●	●	●
Oranges	●	●	●	●	●						●	●
Peaches					●	●	●	●	●			
Pears	●							●	●	●	●	●
Peas				●	●	●	●	●				
Peppers, bell							●	●	●	●	●	●
Persimmons									●	●	●	●
Plums						●	●	●	●			
Pomegranates									●	●	●	●
Potatoes	●	●	●	●	●			●	●	●	●	●
Radishes	●	●	●	●	●	●	●	●	●	●	●	●
Raspberries					●	●	●	●	●	●		
Spinach	●	●	●	●	●	●	●	●	●	●	●	●
Strawberries			●	●	●	●	●	●	●	●		
Squash, summ					●	●	●	●	●	●	●	
Squash, winter	●	●							●	●	●	●
Tomatoes						●	●	●	●	●	●	



Community-Supported Agriculture

Community-Supported Agriculture (CSA) refers to a particular network or association of individuals who have pledged to support one or more local farms. CSA members subscribe for a defined length of time for a share of the anticipated harvest; once harvesting begins, they receive weekly shares of vegetables and fruit.

Why should you sign up for a CSA?

- Saves time and money!
- Weekly access to fresh, local produce
- Exposure to new varieties of fruits and veggies, try new things!
- Build a relationship with the farmer who grows your food
- Invites to member-only events on the farm such as u-picks, farm tours, potlucks and more.

Is a CSA right for you? Things to consider when choosing your CSA:

- Do you like to cook and does your schedule allow you to make homemade meals most evenings?
- How will you handle access produce?
- What are the payment options for each farm? Would you prefer to pay monthly, weekly, or for the whole season up front? Some of the farms listed here allow for weekly subscription payments; visit their respective websites to see if this option is offered.
- Is there a drop-site near your house? For the purposes of this guide, we've only listed drop-off sites that fall within San Benito and Santa Clara County lines. Please visit the websites of the farms for their full list of drop-off sites throughout the Bay Area. Don't see a drop-off site in your area? Contact the farm to see if they would be willing to deliver to a location near you!

How to get your weekly produce box:

Most farms will have designated drop-off sites where you pick up your weekly box of produce on a particular day of the week and time period. Drop-off sites can be a residence, business, school or other public space and are typically un-manned.

Blue House Farm, Pescadero

650-879-0704
info@bluehouseorganicfarm.com
bluehouseorganicfarm.com
Drop site(s): Palo Alto

Blue House Farm is a place that recognizes and nourishes the connection between good food, the natural world and our community. We grow a diverse variety of certified organic produce, fruit and cut flowers on forty acres nestled in the small agricultural valley of Pescadero. Our CSA box program serves our neighbors in San Francisco and the Peninsula from May through December. We offer flexible schedules and payment options, as well as a variety of add-on items.

Edible Acres Farm, San Martin

408-314-7025
jose.teamtierra@gmail.com
www.teamtierra.com
Drop site(s): San Jose

Edible Acres provides private culinary garden plots for restaurant clients and grows rare fruits and vegetables for sale to CSA members and Fresh Carts vendors.

Freshness Farms, Santa Clara Valley

408-520-1272
csa@freshnessfarms.com
www.freshnessfarms.com
Drop site(s): San Jose, Saratoga, Santa Clara, Sunnyvale, Cupertino, Mountain View, Palo Alto

Freshness Farms is a suburban farm, planting and harvesting at various locations throughout the South Bay. Freshness Farms promotes the growth of California Native Edibles and other environmentally friendly growing methods such as Aquaponics.

Frog Hollow Farm, Brentwood

925-634-2845 ext. 206
csa@froghollow.com
www.happychildcsa.com
Drop site(s): Campbell, Los Altos, Los Gatos, Mountain View, Palo Alto, San Jose, Santa Clara, Sunnyvale

Frog Hollow is an organic orchard growing a diversity of tree fruit that is full of flavor, texture and nuance for their all fruit CSA. They take an integrated systems approach to their production by making their own compost, maintaining habitat for beneficial insects and pollinators, and providing nesting sites for owls, bees, and bats on their farm.

Full Belly Farm, Capay Valley

800-791-2110
csa@fullbellyfarm.com
fullbellyfarm.com
Drop site(s): Mountain View, Palo Alto

Full Belly Farm is a certified organic farm that is committed to fostering sustainability on all levels, from fertility in our soil and care for the environment, to stable employment for our farm workers. We strive to be good stewards of this farm, so that this generation and future generations may continue to be nourished by the healthy and vibrant food that we produce.

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Full Circle Farm, Sunnyvale

408-735-8154
csa@fullcirclesunnyvale.org
www.fullcirclesunnyvale.org
Drop site(s): Tues and Thurs pick up at the farm

Cultivating eleven acres in Sunnyvale, Full Circle Farm feeds the community through a CSA, farmstand, and educational programs. Produce includes the best of the season's veggies and fruit. The farm's educational programming offers a farm-based curriculum with hands-on experience for both young people and adults.

High Ground Organics, Watsonville

831-254-4918
csa@highgroundorganics.com
csa.farmigo.com/join/highgroundorganics/csa
Drop site(s): Campbell, Cupertino, Los Altos, Los Gatos, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Willow Glen

High Ground Organics is a family farm located in Watsonville, CA, dedicated to environmental stewardship and producing high quality, fresh, nutritious vegetables for our community.

J&P Organics, Salinas

831-578-9479
jp@jporganics.com
www.jporganics.com
Drop site(s): Campbell, Los Gatos, Palo Alto, San Jose

J&P Organics is a small family run farm located in Salinas, CA providing seasonal produce in the form of Community-Supported Agriculture boxes. The ordering system is run mostly online with weekly emails listing the weeks' produce and a pay-as-you-go system of online ordering with a no commitment policy.

Live Earth Farm, Watsonville

831-763-2448
farmers@cruzio.com
www.liveearthfarm.net
Drop site(s): Campbell, Cupertino, Gilroy, Los Gatos, Morgan Hill, Mountain View, Palo Alto, San Jose, Saratoga, Sunnyvale

We welcome you to experience a direct connection with our farm. We strive to establish a meaningful connection to local food and farming by growing food that nourishes personal well-being, strengthens relationships to family and friends, and teaches us care and respect for the land.

Morris Grassfed Beef, San Juan Bautista

831-623-2933
info@morrisgrassfed.com
www.morrisgrassfed.com
Drop site(s): Gilroy, Hollister, Morgan Hill, Palo Alto, San Jose, San Juan Bautista

We sell 100% grassfed and finished beef, grown on ranches along the Central Coast. We are a family-owned ranch and have been direct marketing our beef to family and friends in California for the past 23 years.

Oya Organics, Hollister

510- 847-5358
falafelita@gmail.com
www.oya-organics.com
Drop site(s): Palo Alto, two locations in San Jose

We are a young farming family, bringing a youthful mix of agroecological and traditional knowledge background to the farm. We currently produce on 12 acres of certified organic land in Hollister, California and distribute our produce directly to the local community.

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Farm-to-Fork Takes Root

Chef Bruno & Welten Farms

Chef Bruno Chemel stands in farmer Ronald Welten's kitchen, looking over bags of Thai basil, eggplant, mint, strawberries and peppers, all grown organically on 1.5 acres just for Chef Bruno and his restaurant. The chef thinks aloud about how the summer's bounty will be incorporated into the menus at Baumé, his Michelin-starred restaurant that's been serving delicious modern French cuisine in Palo Alto since 2010.

This scene represents the ideal relationship between farmer and chef, where collaboration and mutual respect are key components. Ronald and Bruno met in early 2013, after an introduction by CAFF. The two quickly developed a working relationship and understanding, which both attribute in part to their common European background (Chef Bruno is French, while Ronald is from Holland). When asked why he decided to open a restaurant with a focus on food that is local, organic and seasonal, Chef Bruno says, "It's just the way we do things in France."

"Build the relationship with the chef."

In France, he explains, " 'farm-to-fork' is not a trend like it is in the United States; it's just how things are done." For restaurant owners from his part of the world, it's common sense to source the freshest, tastiest fruits and veggies from your local farmer, whether it's from the local produce market or from backyard kitchen gardens.

Every other week, Chef Bruno drives roughly an hour south from Palo Alto to Welten Farms in Gilroy to pick up his produce from Ronald.

Chef Bruno recognizes this isn't typical of most chefs who purchase from local farmers, but he enjoys spending time on the farm, and seeing and smelling the product while it is still in the ground to ensure it meets his taste and quality standards. Chef Bruno's advice for chefs looking to source from local farmers: "Don't be picky, don't be stuck on a particular item, don't force it, be flexible."

From the farmer perspective, Ronald offers this advice:

"Get a good understanding of what the restaurant needs. Go there, have dinner, get a feeling for what the chef is like, this is very important. Build the relationship with the chef. The only reason I am able to work with Bruno like this is I only deliver quality. If it's not good, it's not going to go there. As a farmer, try and pick varieties that have flavor, [for example] older varieties, heirloom varieties. Get as much information on the varieties that you grow as possible, just to make sure you pick the right stuff."

Ronald will soon be adding nearly 40 acres to his farm, in order to sell to an organic produce distributor in San Francisco. He will continue production planning with Chef Bruno every season, ensuring that Baumé will feature fresh, local and delicious produce from his farm for years to come.

Visit Baumé Restaurant at 201 S. California Ave. in Palo Alto. See Welten Farms' listing in the "Farms" section of this guide for contact information.

in Santa Clara Valley

Flea Street Café Owner Jesse Cool

by Rosemary Quinn

Jesse Ziff Cool was doing "farm-to-table" before it was hip. A true Alice Waters of the South Bay, Jesse opened the first organic restaurant in the country, Late for the Train, in Menlo Park 38 years ago.

Jesse grew up in small farming community in rural Western Pennsylvania, and was taught the value of knowing the origin of her food at an early age. Those values translated into the restaurant's practice of not using preservatives, growth hormones or artificial ingredients; everything was organic.

Jesse remembers apologizing to customers that it took so long to prepare the food, due to their commitment to make everything from scratch with only the best ingredients.

In 1980, Jesse opened Flea Street Café in Menlo Park. Today, Jesse Cool Restaurants and Catering is made up of Flea St. Café, Cool Café at Stanford, Cool Café at Menlo Business Park and Jesse Cool Catering, which all purchase fresh produce from numerous local farmers such as Full Belly Farm, Webb Ranch, Coke Farm, Molino Creek, and CJ Olson Cherries. Carrying forward the philosophy she had started at Late for the Train, all of the farmers she works with are listed on the menu by name.

"Carrying forward the philosophy she had started at Late for the Train, all of the farmers she works with are listed on the menu by name."

Chef Carlos Canada joined Flea Street a few years ago, working his way up in the restaurant industry from dishwasher to Sous Chef, to Executive Chef. Jesse admires how Chef Carlos is very respectful of the history of the restaurant and of the farmers.Jesse talks about how she felt comfortable introducing him to her farmer friends and how Chef Carlos "just gets it." She stresses how he really cares about the ingredient-driven philosophy of the restaurant, the focus on the integrity of the product, and of not hiding the ingredient or masking the food.

Jesse is excited by the change she has witnessed in the restaurant scene over the last five years. The next generation is beginning to realize the old way of cooking, and the younger generations want to know and learn about the integrity of their food. Jesse has witnessed a change in the clientele at her restaurants as well -- a younger crowd that understands the true cost of the food and the value of those who helped make it.

As far as the future of the movement, Jesse stresses the importance of preserving farmland for future generations. Jesse believes that saving farmland is really the only way to make sure the movement is sustained. Jesse supports the idea that we have to shift the model to really support production farmers. This movement is not just for the elite, but for everyone who eats and lives here.

Flea Street Café is located at 3607 Alameda de las Pulgas in Menlo Park. For more information about the other restaurant locations and catering, visit www.cooleatz.com.

Member Listings

All of the farms and businesses listed in this guide are CAFF members and have joined the Buy Fresh Buy Local campaign. As members, businesses commit to purchasing from and promoting local farms and food.

Buy Fresh Buy Local businesses - like grocery stores, food artisans, restaurants, caterers and food service companies - often source-identify by farm name and location, while distributors have created local lines that identify local products for their clients. While many of the distributors are based outside of the Valley, they have committed to purchasing from our local farmers.

Farmer members use sustainable agricultural practices to maintain healthy soil, water, air, and habitat and are owned by family members who are actively engaged in running the farm. Many of the farms are open to the public for farm stands and events. Refer to the key in the farm listings to see where you can find farm-fresh produce.

To try out a new farmers market, see the farmers market listing or find a weekly produce box that's right for you on the CSA page! We invite you to use the listings in this guide to support Buy Fresh Buy Local members and further your own local food commitment.

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Timptations, Santa Clara Valley

info@timptations.com
www.timptations.com
Drop site(s): Pick up sites and home delivery available for most cities within the Santa Clara Valley. Visit website for a complete list of locations.

TIMptations is family owned & operated by 3rd generation Santa Clara County farmer Tim Chiala. We also service corporate cafes, restaurants & caterers.

Veggielution, San Jose

408-634-3276
info@veggielution.org
veggielution.org/farmbox
Drop site(s): 4 San Jose Locations: Veggielution Community Farm, Williams Street Park / Olinder School, The Studio Climbing Gym (1st and San Salvador), South Willow Glen

Farm Box members are part of the Veggielution family - dedicated supporters who want to keep San Jose's agricultural heritage alive, and who are helping to create a more sustainable, equitable food system here in the South Bay. By becoming a seasonal member, you will not only receive the very best of Veggielutions produce, you will know your membership goes to support their various community programs.

END OF CSA LISTINGS

Farms

Abounding Harvest

831-275-0610
Los Gatos, CA 95033
contact@aboundingharvest.com
www.aboundingharvest.com

We are a family farm located in the Santa Cruz Mountains. We specialize in sub-tropical fruit and summer vegetables. We have avocado and citrus groves, as well as blocks of pomegranates, kiwis, and persimmons. Our vegetable crops differ from year to year, but always feature onions, potatoes, peppers, tomatoes, and tomatillos in the hot season. Our fruit harvest occurs during the rainy season, with pomegranates and kiwis in the fall followed by different varieties of citrus and avocados in the spring.

Selling at: Santa Cruz restaurants: Penny Ice Creamery, The Picnic Basket, Assembly and Ristoranti Avanti. Also sell to Frog Hollow Farm and Local Harvest.

Andy's Orchard

408-782-7600
1615 Half Rd.
Morgan Hill, CA 95037
andysorchard@andysorchard.com
www.andysorchard.com

Expert orchardist Andy Mariani specializes in new and heirloom varieties of tree-ripened stone fruit, including sweet cherries, apricots, peaches, nectarines, and plums. He hosts tastings and tours at the orchard, and offers products for sale through their website and farmstand.

Selling at: Andy's Orchard online store and mail order, farm stand, specialty stores

C.J. Olson Cherries

408-736-3726
348 W. El Camino Real
Sunnyvale, CA 94087
info@cjolsoncherries.com
www.cjolsoncherries.com

Visit our historic fruit stand, known for Bing cherries and Blenheim apricots. Experience the fun and the delicious treats at Olson's.

Selling at: On-site fruit stand, San Jose and Oakland airports

Coke Farm

831-623-2100
San Juan Bautista, CA 95045
ccattin@cokefarm.com
www.cokefarm.com

Going into our 35th year of farming, we are still offering a well-rounded array of organic fruits and vegetables, always aiming for highest quality of product and service, and providing a fair and enjoyable work place to our employees.

Selling at: Palo Alto Farmers' Market

ECOPIA Farms

1520 Dell Ave.
Campbell, CA 95008
sales@ecopiafarms.com
www.ecopiafarms.com

We are an organic, indoor, urban farm, producing fresh, pristine produce year round. We deliver to local chefs, and consumers a variety of tasty greens, herbs and other produce.

Selling at: Bay Area restaurants, home delivery and farmers markets (Los Altos, Los Gatos, Saratoga)

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SALES METHOD

FARMERS MARKET · FARM STAND · RESTAURANTS · ONLINE · WHOLESALE / RETAIL / GROCERY · CSA

CONTINUED FROM PAGE 16

Edible Acres Farm

408-314-7025
13385 Murphy Ave.
San Martin, CA 95046
jose.teamtierra@gmail.com
www.teamtierra.com

Edible Acres provides private culinary garden plots for restaurant clients and grows rare fruits and vegetables for sale to CSA members and Fresh Carts vendors.

Selling at: La Cosecha mobile produce cart

Fairhaven Orchards

831-637-4221
1448 Bolsa Road (Hwy. 25)
Hollister, CA 95023
www.fairhavenorchards.com

Visit Fairhaven Orchards for the finest Bing and Rainier Cherries, fresh and dried Blenheim Apricots. Family-owned and operated since 1958.

Frazier Lake Farms

831-902-7806
1090 Hudner Lane
Hollister, CA 95023
halperin@calcon.us

Frazier Lake Farms has been farming in Hollister for 28 years. The Halperins and their three children live off-the-grid in a solar-powered house. They produce a variety of vegetables and herbs, including heirloom tomatoes, red peppers and winter squash. The farm sits on 100 acres, including 35 acres of greenhouses.

Selling at: Veritable Vegetable

Freshness Farms

408-520-1272
csa@freshnessfarms.com
www.freshnessfarms.com

Freshness Farms is a suburban farm, planting and harvesting at various locations throughout the South Bay. Freshness Farms promotes the growth of California Native Edibles and other environmentally friendly growing methods such as Aquaponics.

Full Circle Farm

408-735-8154
1055 Dunford Way
Sunnyvale, CA 94087
info@fullcirclesunnyvale.org
www.fullcirclesunnyvale.org

Cultivating eleven acres in Sunnyvale, Full Circle Farm feeds the community through a CSA, farmstand, and educational programs. Produce includes the best of the season's veggies and fruit. The farm's educational programming offers a farm-based curriculum with hands-on experience for both young people and adults.

Selling at: On-site farm stand and Santa Clara Valley restaurants and schools

Garnish Garden

408-507-7001
Sunnyvale, CA 94087
garnishgarden@gmail.com
www.garnishgarden.net

Based in Sunnyvale, California, Garnish Garden has produced micro greens for local fine restaurants since 2011. Our artisanal greens are sown and grown right here on our own micro farm, and are delivered living, in soil, directly to your kitchen.

Selling at: Santa Clara Valley restaurants including: Chez TJ, Plumed Horse, Lexington House, Dio Deka, Parcel 104 and The Table

Gibson Farms, Inc.

831-637-3512
1190 Buena Vista Rd.
Hollister, CA 95023
mark@gibsonfarmsinc.com
www.gibsonfarmsinc.com

Gibson Farms is proud to grow and process heirloom Blenheim Apricots, which are picked off the trees and the perfect stage of ripeness, cut into halves and then dried in the California sun.

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GET TO KNOW...

Cloud9 Orchard and Olive Oil

by Zea Luce

A newcomer on the scene, Cloud 9 Olive Oil has won awards every year since its beginning, proving its worth and quality. The organic and sustainable practices used by owner May Chevallier produce a distinctive product that now has a strong and loyal following. Most recently her oil won the Gold and Best of Class awards at the Mid-State Fair Competition.

The business took root in 2007 when Mrs. Chevallier decided to act on her desire to grow food commercially. She attended farming workshops and seminars at UC Davis Extension, where she learned about olive growing, followed by the sensory olive oil tasting seminars that really got her hooked! During this process, Mrs. Chevallier discovered that her maternal grandfather was an orchardist in China specializing in Lychee nuts; she believes this is why she has always had the desire to own land and grow food.

In 2008 Mrs. Chevallier purchased land in the rolling hills of Monterey County's San Antonio Valley and started her olive orchard. The orchard is planted with 10 different olive cultivars that she blends into three varietal oils. Mrs. Chevallier is largely able to run the business from her home office in Palo Alto with the help of a reliable orchard foreman to assist in the field. Organic rodent control, weed management, and drip irrigation inspection occur year-round. She also performs periodic leaf analysis to determine the trees' nutrient profile, and organic nutrients are applied as needed. In the beginning, it was a steep learning curve. There were "more errors than trials" in the earlier years, she said.

At harvest time, in addition to a large crew of olive harvesters, the family invites friends and customers to volunteer in the orchard. Harvest means praying for a fine day and coordinating with the miller and enough labor to make for a smooth day of harvesting. Mrs. Chevallier hires a mobile mill to press the oil immediately after picking, and then sends the oils to a lab to certify that they are fresh and authentic. The California Olive Oil Council performs blind taste tests to judge the quality of the oil and bestows their seal of approval for extra virgin grade olive oil. Mrs. Chevallier has won a number of awards in regional and national competitions. She markets much of her oil to local businesses in the San Francisco Bay Area and hopes to expand sales to national and international markets.

For more information, please visit:
www.cloud9orchard.com

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Gilroy Demonstration Garden

949-981-0268
7360 Eigleberry St.
Gilroy, CA 95020
gilroydemonstrationgarden@gmail.com
www.gilroydemonstrationgarden.org

The mission of the Gilroy Demonstration Garden is to enrich the lives of our local community through environmentally sustainable gardening and education programs that empower residents to experience the Earth as a classroom, an edible landscape, the center of our community, and a place of enjoyment, beauty, and endless wonder.

Selling at: Gilroy Farmers' Market, Milias Restaurant

Ground Stew Farms

408-634-3311
13525 Center Ave.
San Martin, CA 95046
sergio.jmnz@yahoo.com

Sergio worked in the manufacturing industry for 15 years building parts for the high-tech industry before realizing that his real passion was farming. In 2009, Sergio completed the ALBA beginning farmer-training program. 5 acres of certified organic land and growing, Ground Stew produces a wide variety of vegetables from fennel to kale.

Selling at: Bay Area farmers markets

Hain Ranch Organics

831-628-3390
608 Bolado Rd.
Tres Pinos, CA 95075
mail@hainranchorganics.com
www.hainranchorganics.com

Hain Ranch Organics is a small family farm and ranch bordering the Tres Pinos Creek. Paul and Leti Hain produce and market CCOF-certified walnuts, pastured poultry, and heirloom tomatoes.

Heirloom Organic Gardens

831-637-8497
743 Shore Rd.
Hollister, CA 95023
sales@heirloom-organic.com
www.heirloom-organic.com

Growing everything from tasty specialty Spinaches to exotic and not so exotic Greens, an amazing array of Root Crops, Walnuts and Fruit, Vine Crops, Herbs and medicinal plants here in San Benito County, food is fun! The farm grows over 200 products, an astonishing number of which are grown year round or near year round, including many exclusives.

Selling at: Hollister, Gilroy, Saratoga, Mountain View, and Palo Alto Farmers' Markets, Coke Farm, Bay Area restaurants including: Chez TJ, Madera, Plumed Horse, Forest on First

Las Hermanas CC Produce

831-207-3628
440 Shore Rd.
Hollister, CA 95023
lashermanasccproduce@yahoo.com

In 2011 our family decided to start our own farm. Our whole family is involved in running Las Hermanas. Mom, dad, a brother and two sisters manage everything from the field to customer sales. We started small, and in three years we have grown to 60 acres.

Selling at: Coke Farms, J&W Produce, ALBA Organics

Morris Grassfed Beef

831-623-2933
500 Mission Vineyard Rd.
San Juan Bautista, CA 95045
info@morrisgrassfed.com
www.morrisgrassfed.com

We sell 100% grassfed and finished beef, grown on ranches along the Central Coast. We are a family-owned ranch and have been direct marketing our beef to family and friends in California for the past 23 years.

Selling at: Online at www.morrisgrassfed.com/order

Oya Organics

510- 847-5358
Hollister, CA 95023
falafelita@gmail.com
www.oya-organics.com

We are a young farming family, bringing a youthful mix of agroecological and traditional knowledge background to the farm. We currently produce on 12 acres of certified organic land in Hollister, California and distribute our produce directly to the local community.

Selling at: Santa Clara University Dining Services, New Leaf Community Markets-Evergreen, Zannoto's Family Market in San Jose, Caffe Riace and Tin Pot Creamery in Palo Alto. Also selling at Santa Clara Valley Farmers Markets, including Indian Health Center, San Pedro Square Market, Morgan Hill, Mountain View and Belmont.

Paicines Ranch

831-628-0288
P.O. Box 8
Paicines, CA 95043
info@paicinesranch.com
www.paicinesranch.com

Paicines Ranch has been a working ranch since the mid-1800s. They offer delicious grassfed and grass-finished beef seasonality as split-halves, halves, or wholes, and year-round in a variety of packaged retail cuts. Their mission is to preserve the ranch for future generations, and their products are all processed by small independent plant in Newman.

Penny Lane Farm

831-524-3671
25 Daffodil Dr.
Hollister, CA 95023
1tomatomama@gmail.com
www.1tomatomama.com

For the last 5 years, from March to June, husband and wife team Diane and Dan Matarangas grow and sell organic vegetable starts from all over the world, including 150 different varieties of heirloom tomatoes, 50 varieties of peppers and 20 varieties of eggplants.

Selling at: Hollister, Saratoga, Morgan Hill, Mountain View, and San Jose Blossom Hill farmers' markets

Phil Foster Ranches & Pinnacle Organic Produce

831-623-9422
P.O. Box 249
San Juan Bautista, CA 95045
pfoster@pinnacleorganic.com
www.pinnacleorganic.com

Cultivating and marketing a wide variety of organic vegetables and fruits, Phil Foster Ranches strives to provide high quality products for their customers, excellent compensation and benefits for their employees, and the best possible care for the land.

Ritter Ranch

831-637-1356
565 Santa Ana Valley Rd.
Hollister, CA 95023
akr830@aol.com

Shady Creek Farm

510-845-6301
14490 Watsonville Rd.
Morgan Hill, CA 95037
shadycreekfarmca@gmail.com
www.shadycreekfarm.info

Shady Creek Farm provides fresh from the farm products including, pastured eggs, jams, and a variety of baked goods.

Selling at: Shady Creek Farmstand

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Sherrie's Farm

408-842-5862
6930 Holsclaw Rd.
Gilroy, CA 95020
shersfarm@hughes.net
sherriesfarm.com

Sherrie's Farm is a small family-owned operation that specializes in growing certified organic heirloom and specialty tomatoes. Our purpose is to carefully produce and package heirloom tomatoes of exceptional quality without the use of pesticides, synthetic fertilizers or fumigants while practicing stewardship of the land and of the other natural resources.

Spina Farms

408-463-0125
8820 Santa Teresa Blvd.
San Jose, CA 95141
www.spina-farms.com

Spina Farms sells homegrown produce at their on-farm produce stand, with a pumpkin patch, petting zoo and hay rides in the fall.

Selling at: Farmstand and wholesale

Swank Farms Produce, Inc.

831-367-4704
645 Lanini Dr.
Hollister, CA 95023
mccauleymf@aol.com
http://www.swankfarms.com

Dick and Bonnie Swank are owners of Swank Farms Produce, Inc. in Hollister California. They farm sixty acres at the home ranch, property that was purchased by Dick's grandfather Bill Maggini in 1929, along with 240 acres at a satalite location.

The Salad Farm

831-663-3311
17813 Country Side Ct.
Salinas, CA 93907
joyce@thesaladfarm.com
www.thesaladfarm.com

The Salad Farm is a family-owned operation based in Salinas, California. We are committed to growing, processing and sales of the finest quality produce available. Our growers are devoted to the cultivation and harvest of the best quality spring mix, spinach and arugula.

Selling at: Wholesale and other retail markets

TIMptations

1565 Maple Ave.
San Martin, CA 95046
info@timptations.com
www.timptations.com

TIMptations Farm is family owned & operated by 3rd generation Santa Clara County farmer Tim Chiala. TIMptations Farm offers a CSA program (see CSA section of this guide for more information). We also service corporate cafes, restaurants & caterers.

Uesugi Farms

408-847-9401
1020 California 25
Gilroy, CA 95020
pete@uesugifarms.com
www.uesugifarms.com

Uesugi Farms is a grower, packer and shipper of various fruits & vegetables. We also operate three farmstands from April through August and a pumpkin patch in October.

Selling at: Chef's Choice, Daylight Foods, LJB Farms, George Chiala Farms/Timptations, Golden Rule Produce, Gaili Produce, various farmstands located throughout Gilroy, Morgan Hill, and San Jose, Lunardi's, Safeway, Albertson's, SaveMart, Chong's Produce, T&S Produce, J&S Produce, Whole Foods, Trader Joe's

Van Dyke Organics

408-483-3636
7665 Crews Rd.
Gilroy, CA 95020
pvandyke@earthlink.net
www.vandykeorganics.com

The Van Dykes are a 5th generation Californian family farm specializing in organic dried fruit. They have been producing fruit for their Gilroy ranch since 1921-most notably the Blenheim apricot! They also grow bing cherries and will be diversifying into walnut and grape growing in the coming years.

Veggielution

408-634-3276
info@veggielution.org
veggielution.org/farmbox

Veggielution Community Farm's classes and volunteer programs inspire happier and healthier lives while also growing fresh produce for our neighbors in the South Bay that need it most. By cultivating a space where everyone feels included, Veggielution breaks down barriers that keep people apart, uniting South Bay residents across all generations, incomes, and cultures.

Vintage Farms

831-265-1405
7171 Lovers Ln.
Hollister Ca, 95023
vintagefarms201@yahoo.com

We are a family owned family operated farm that specializes in heirloom tomatoes. We also grow kales, chards and many other seasonal vegetables.

Welten Farms LLC

831-710-7407
2985 Roop Rd.
Gilroy, CA 95020
weltenfarms@hotmail.com

Welten Farms is a certified organic family farm in South Santa Clara County. We grow heirloom vegetable varieties for top chefs in the SF Bay Area. Among our customers are Michelin star rated restaurants.

Selling at: Baume Restaurant (Palo Alto) and Veritable Vegetable (San Francisco)

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New Leaf Community Markets

Embracing Buy Fresh Buy Local

by Allie Hoffman

It can be hard to find a company that has remained committed to their original values, yet New Leaf Community Markets has done just that.

Beginning as the Our Neighborhood Food Co-op in Santa Cruz, owner Scott Roseman then opened the Westside Community Market in 1985, which later developed into what we know today as New Leaf Community Markets.

Staying true to their mission to "nourish and sustain their community," New Leaf includes local organic farmers as part of their community. Because of this, they were among the first Buy Fresh Buy Local supporters in California and continue to remain faithful to that tenant today.

While New Leaf began in Santa Cruz, they have since expanded to Half Moon Bay, Pleasanton and San Jose. Despite expansion, they continued to purchase on a scale that is local to their individual stores. At New Leaf, food that is considered local needs to be produced within a 100 mile radius. Because there are 1,693 farms in the Santa Clara Valley, there is no shortage of local growers that they can feature in their San Jose store.

In a world where the food system is built for produce to travel around the world before it reaches our tables, New Leaf feels like they have an advantage over other stores in terms of quality. By receiving deliveries directly from farmers, they can turn produce around from farm to customer faster than retailers that rely on a central distribution model. New Leaf is quick to point out that they can't always source directly from local farms because of what is available seasonally. Still, Maroka Kawamura, New Leaf's Produce Director says that they always prioritize local organic food over any alternative. Each individual store has

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a produce manager that Kawamura oversees. While she works to approve new vendors, the Produce Manager handles the purchasing for their own store. This way they can meet the unique needs of their individual customers and select products based on geographic location. The Evergreen store, in San Jose, for example, has a different set of local vendors (farmers) than the Half Moon Bay store.

Despite the commitment to their original values, their growth has not been without criticism. In late 2013, New Leaf and New Seasons Market, a Portland, OR-based grocer, merged. Because New Seasons carries some conventional (non organic) products, some consumers pushed back fearing that New Leaf may begin to do the same. Roseman says that this is not the case and each company will continue to operate independently. Both companies are interested in continuing to grow and expand, and by joining forces they have more clout to be able to do so. Kawamura believes that the merger will help farmers in our region because opening new stores will allow them to purchase more produce from local farmers.

When asked about Buy Fresh Buy Local, New Leaf said, “We love the [Buy Fresh Buy Local] program. It dovetails very nicely into the local focus we put on our products and produce department specifically. We use [Buy Fresh Buy Local] graphics on all of our produce signs so that customers can quickly distinguish if an item is grown within 100 miles of their store.”

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Grocery Stores

Monta Vista Market

408-777-0330
21666 Stevens Creek Blvd.
Cupertino, CA 95014
manager@montavistamarket.com
www.montavistamarket.com

Monta Vista Market embraces the “Slow Food” movement by promoting high quality, fresh and local, non-processed healthy foods that are organic, without additives, and GMO-free. Half our store is organic fruits and vegetables - the remainder features organic chicken, grass-fed ground beef, pork and bacon, organic dairy, raw milk and cheeses, organic nuts and snacks, Amy’s frozen entrees, plus a variety of organic beans, rice, grains, snacks, dry goods, canned and frozen items, condiments, juices, teas, coffee plus healthy grab-n-go.

New Leaf Community Markets

408-513-8200
5667 Silver Creek Valley Rd.
San Jose, CA 95138
info@newleaf.com
www.newleaf.com

New Leaf’s mission is to nourish and sustain our community. See article in this guide for more information about how New Leaf supports local farmers.

Oak Grove Market

650-477-2127
1000 Oak Grove Avenue
Burlingame, CA 94010
info@oakgrove-market.com
oakgrove-market.com

Our goal from the outset at Oak Grove Market has been to upgrade this small convenience store back into a true neighborhood market. We continue to carry many national brands but also feature numerous premium quality items with a particular emphasis on local small producers. We’re proud to be - and proud to support other independent small local businesses.

Specialty Stores & Food Artisans

Barefoot Coffee Roasters

408-293-7200
2475 De La Cruz Blvd.
Santa Clara, CA 95050
justine@barefootcoffee.com
www.barefootcoffee.com

We are a small batch, local specialty coffee roastery. We strive in building relationships with farmers as well as customers and have been direct trade for over 10 years.

Cloud 9 Orchard

650-776-6962
168 Tennyson Ave.
Palo Alto, CA 94301
may@cloud9orchard.com
cloud9orchard.com

Grower and producer of award winning Extra Virgin Olive in Monterey County.

Find at: Country Sun Natural Foods, Draeger’s Market, Dittmer’s Wurst-Haus, Full Circle Farm of Sunnyvale, GoodEggs, Milkpail Market, Monterey Wharf Marketplace, Spina Farm and Veggielution

CurryFresh

info@asianseasons.com
www.asianseasons.com

CurryFresh is an authentic South East Asian curry paste that is vegan, gluten free, all natural with zero preservatives and is handcrafted in the South Bay using fresh ingredients from local family farms.

Find at: You can find CurryFresh at your local Whole Foods Market and New Leaf Community Markets

Frantoio Olive Grove

408-391-0013
10756 Green Valley Dr.
Gilroy, CA 95070
jeff@frantoiogrove.com
frantoiogrove.com

Frantoio Grove produces COOC certified Extra Virgin Olive Oil in Santa Clara County, with 150 years of a family tradition revived in the heart of California.

Find at: Online and at Clos La Chance Winery, CJ Olson Cherries, Draeger’s Market, LJB Farms, Guglielmo Winery, Rocca’s Market, Solis Winery, Zannatto’s Market’s, Cordevalle’s II Vigneto Restaurant, Andy’s Orchard Farm Stand

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Urban Agriculture in the Santa Clara Valley
- Educational and Community Farms

by Zea Luce

Despite the urbanization of northern Santa Clara County in the last 50 years, some farms have remained and exist today as educational farms and others have sprouted up, filling the niche of what has become known as "urban agriculture." Urban agriculture takes many different forms (for example, rooftop gardens, guerilla gardens, vacant lots, community gardens, and indoor and educational farms), but often includes a community or educational aspect. They may offer classes, host volunteer work days, and promote nutrition and access to fresh produce. This area is home to many such organizations, several of which are highlighted below. Please see the Local Partners and Community Resources page for a longer listing of organizations in our region.

Emma Prusch Farm Park

Preserving agriculture amidst busy freeways and shopping centers in San Jose

Offering a wealth of farm-oriented programs, this 47-acre park sits juxtaposed against both the 101 and 280 freeways in east San Jose. Thanks to a generous donation from Ms. Emma Prusch in 1962, visitors today may experience farm tours, tend community garden plots, participate in summer camps, feed and view animals, take classes, attend festivals, or have picnics. Where there was once pasture land, and then a dairy farm for 100 years, there is now a bustling educational farm, complete with free-ranging fowl. Ms. Prusch deeded the property to the City of San Jose with two conditions: that it remained a farm park and that it was accessible to the public. Today the park reaches over 10,000 local residents annually with classes and programming, and hosts 200,000 visitors. The park is home to the "Hatchery" pre-school and a large barn where 4H members raise livestock. While visitors can tour the farm park on their own, the naturalists also offer guided tours that include hay rides, pumpkin picking, butter-making, or seed sowing. Other specialty classes and events consist of cheese-making, pizza-making, campfires, insects, composting, or naturalist-led animal chores. The children who attend summer camp are able to feed the animals, grow their own food, do crafts, and have a barbeque with vegetables they grew themselves. Take some time to visit the park and experience life on a farm!

647 S. King Rd
San Jose, CA 95116
www.pruschfarmpark.org

Veggielution Community Farm

Putting down roots in a San Jose community

Veggielution is a non-profit community farm dedicated to bringing Bay Area residents together around food and farming. The 6-acre farm, located within the Prusch Farm Park, runs several programs that provide healthy food to families in need and educates children and adults about gardening, healthy eating, and sustainable lifestyles. Individuals and groups can volunteer on the farm during the weekly workdays and families with children can participate in free garden activities every Saturday. The subscription Farm Box Program and Saturday Farm Stand provide customers with a variety of fresh vegetables each week, while generating income that supports the community programs. Veggielution offers a place to meet new people and create authentic, meaningful connections. Please visit their website for more information.

647 S. King Rd.
San Jose, CA 95116
www.veggielution.org

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Deer Hollow Farm
A historic, educational farm in Los Altos

The Rancho San Antonio Open Space Preserve, in the foothills of Los Altos, is home to Deer Hollow Farm, where visitors can experience a working homestead and view the orchard and animals. The 150-year-old farm is an educational farm that is open to the public, receives school classes, and various community groups. Volunteer docents show elementary students around the farm, the preserve, and a replica Ohlone Village. Volunteers also assist with the livestock, in the garden and orchard, and interact with the public. The farm hosts a summer day camp for local students, where they experience life on a farm, take hikes, play games, and do crafts. Run by the City of Mountain View's Recreation Division, the farm is a delightful surprise to encounter when hiking in Rancho San Antonio!

22500 Cristo Rey Dr,
Cupertino, CA 95014
www.fodhf.org
www.mountainview.gov

Martial Cottle Park
A historic agricultural park in San Jose

Visitors to the newly minted Martial Cottle Park are invited to step back to a time when Silicon Valley was known as the Valley of Heart's Delight. Nestled between freeways, commercial buildings, and suburban communities, the park will provide a welcome respite to the surrounding development while offering a gateway to Santa Clara Valley's agricultural past. The approximately 287-acre park is a fraction of the 6,900-acre Rancho Santa Teresa that once occupied the neighborhood beginning in 1834. Walter Cottle Lester, whose family had continuously farmed the land for over 150 years, staved off development and generously donated part of the property Santa Clara County and sold another portion of the land to the State of California. After the death of his grandfather, Martial Cottle, Lester envisioned developing the land into an agricultural park to be used as educational public property, connecting current and future generations to the rich agricultural history of the region. He, therefore, sought the partnership of the County and the State to implement this vision.

A portion of the park's perimeter trail opened at the end of 2013 and residents of the Santa Clara Valley can now enjoy walking, jogging, and biking on 1.5 miles of new trail that will eventually be completed around the entire perimeter of the park. Residents and visitors of south San Jose can look forward to the continuing development of this unique park. Construction has already begun on many of the park's other planned features, including a 3,500 square-foot visitor center, family picnic areas, and educational resources including a discovery farm, which will allow families to learn about past farming practices. The park will also be home to small agricultural production fields, a community garden, urban forestry program, youth agricultural programs (such as 4-H and Master Farmer programs), and a research and demonstration garden for the University of California Cooperative Extension. Construction on the park is expected to be completed by December 2014. More information and updates can be found at the Santa Clara County Parks Department website.

The park is bounded by Highway 85, Snell Ave, Branham Lane, & Chynoweth Ave in San Jose.
www.sccgov.org/sites/parks/parkfinder/Pages/martialcottle.aspx

Hidden Villa
A non-profit organic farm offering wilderness and environmental education on 1600 acres in Los Altos Hills

Hidden Villa's mission is to inspire a just and sustainable future through community programs, land, and legacy. Founded by the Duveneck family in 1924, the first hostel on the Pacific Coast was established here, as well as the first multiracial summer camp. Today community members can participate in the farm's CSA, view the farm animals, attend workshops, enroll in summer camp, schedule a field trip, pursue an internship, volunteer in any aspect of the farm's operations, hike the 8 miles of trails, and more. The small-scale organic farm teaches about and produces sustainable food – quality vegetables, fruits, meat, and eggs for local markets. Visit their booth at the Los Altos Farmers' Market!

26870 Moody Rd,
Los Altos Hills, CA 94022
www.hiddenvilla.org

Farm to School Programs in Santa Clara Valley

by Zea Luce

"My mom never heard of persimmons before, but now she buys them for me!"

For the last 6 years students in partner school districts throughout the Santa Clara Valley have been learning about fresh, locally-grown fruits and vegetables, visiting farms, and eating them when they appear in cafeterias. These students are part of the Farm to School program at their districts, which is loosely defined as any effort to connect students with fresh, healthy, locally-grown food in cafeterias, classrooms, and communities. There is no packaged program a school can sign up for; Farm to School is an approach adapted to the district's needs. Strong programs coordinate and combine all three legs of Farm to School:

- **Procurement** – local foods are purchased, promoted, and served in the cafeteria
- **Education** – students participate in education activities related to agriculture, food, health, and/or nutrition
- **Gardens** – students grow their own food through hands on learning in the school gardens

"It is not often that my cafeteria staff are included, recognized or made to feel a part of the health movement. I cannot tell you the amount of impact it had on me and my staff when CAFF held the professional development culinary trainings.

- Nalani Battaglia, Food Service Director, Gilroy Unified School District

In the Santa Clara Valley, CAFF's Farm to School program includes:

Harvest of the Month – Teachers receive and are trained on monthly tasting kits that feature fresh fruits or vegetables grown by local, family farms. Students learn about seasonal produce, how fruits and vegetables are grown, what local farmers grow, and the nutrients and vitamins contained in produce.

Farm to Cafeteria – School food service directors collaborate to advance farm to school efforts in the region through the "Farm to School Consortium." They coordinate on recipes and purchasing the monthly local items. In some districts, staff receive culinary training on preparing farm fresh produce and scratch cooking.Farm to School educators dress in fruit or vegetable costumes and hand out produce tastings in the cafeterias to encourage students to eat the local items.

Results! – Collectively, participating districts have achieved the following in 2013-2014:

- An average of **41%** of produce was purchased locally (within 150 miles of their distributor's warehouse in Union City)
- School districts spent and served approximately **$400,000** of local fruits and vegetables to K-12 students
- Of **993 students** receiving Harvest of the Month Tasting Kits each month, **64%** reported increases of fruit and vegetable consumption and **74.5%** reported knowing where their food comes from
- Santa Clara Valley farms **Heirloom Organics Farm, Las Hermanas Farm, Uesugi Farms, Coke Farm, and Sherrie's Farm** are now selling to schools through Fresh Point Distribution Company

To learn more about how your school district can participate, contact ***southbay@caff.org****!*

Participating school districts include:

Gilroy Unified
Moreland
Oak Grove
Franklin McKinley
San Jose Unified
Mountain View Whisman
Sunnyvale Elementary

Harvest of the Month Tasting Kits

Students learn about local, farm-fresh produce, nutrition, and agriculture

HOW IT WORKS

Each month, participating classes from the Central Coast to Hollister to Palo Alto receive a Harvest of the Month Tasting Kit featuring a different locally grown produce item and teaching materials. Students taste the fruit or vegetable, hear about the farmer that grew it, and learn about nutrition. Many of the schools also feature the item in the cafeteria in recipes or on the salad bar! The program runs September to May.

THE FARMERS

Local farmers sell their produce to be packed in school tasting kits. Some past participating farmers in Santa Clara County have included Coke Farm (Easter Egg Radish), Van Dyke Farm (Dried Pear and Apricot), Las Hermanas Farm (Green Beans), and Ground Stew Farms (Kale). Farmer profiles in each kit enable students to learn more about what they grow, where they farm, and why they like farming.

KIDS SAY:

"My plate is already empty!"

"I didn't know oranges could be different kinds of colors, just like apples! Before [HOTM] I thought there was only one kind. I thought an orange was just an orange or an apple was just an apple."

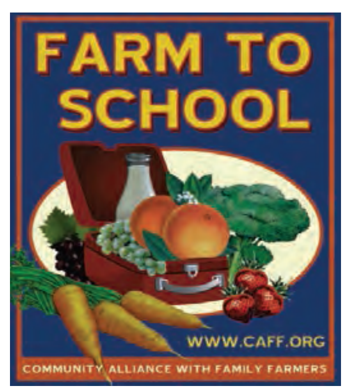
PARENTS AND TEACHERS SAY:

"My daughter is always excited to tell me the different foods she has eaten for the first time. There are times when I am hesitant to give my children a vegetable with their meals, for fear that they might not like it. **This Harvest of the month program has changed my attitude**."
- Parent, Greenfield Union School District

"Your program is such a benefit to our curriculum. We are able to utilize it in all subject areas. **The added benefits are that it is hands-on, 'taste-on', and healthy.** What more could we ask for?"
- Teacher, Sunnyvale School District

HARVEST OF THE MONTH 2013-2014 SCHOOL YEAR NUMBERS

- **54 schools participated in the program**
- **Over 500 produce tasting kits were delivered each month**
- **150,000 students benefited from this program in their classes**
- **$20,000 of produce was purchased from local farmers**



Are you a teacher? The kits provide nine months of engaging standards-based lessons and farm-fresh produce for $15 per class each month, which comes to only 44 cents per student!
Please contact us at harvestofthemonth@caff.org for more information about the program.

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Mission Hill Creamery
408-615-1080
2905 Park Ave.
Santa Clara, CA 95050
chris@missioncitycreamery.com
www.missioncitycreamery.com

Nanny O's
408-209-0849
P.O. Box 870
San Martin, CA 95046
stu@nannyos.com
www.nannyos.com

Grown on a Family Farm and harvested at the peak of ripeness. That garden fresh, nothing artficial, home-made quality is captured in every jar of asparagus, pickles, olives, green beans, mushrooms, and more.

Find at: Sarah's Vineyard in Gilroy, Rocca's Market in San Martin, Guglielmo Winery in Morgan Hill, Riccatoni's Market in Morgan Hill, Sunnyvale Farmer's Market

San Benito Tea Company
13140 Cienega Road
Hollister, CA 95023
info@sanbenitotea.com
www.sanbenitotea.com

Estate grown herbal infusions.

Find at: Bay Area farmers markets, including Palo Alto farmers market

Sons-of-Sicily Olive Oil
831-801-6120
281 Richardson Rd.
Hollister, CA 95023
www.sons-of-sicily.com

We produce Extra Virgin Olive Oil. A blend of five Tuscan varietals, cold pressed and unfiltered. The oil is award-winning and has a very unique flavor which separates it from all the rest.

Find at: San Benito Bene, Casa De Fruta, Bertuccio's Market in Hollister, The Garlic Shoppe and Market 25 in Gilroy, Star Market in Salinas, Pezzini Farms in Castroville, The Whole Enchilada Market Place and Phil's Fish Market in Moss Landing, Pacines General Store in Pacines.

Uva's Gold Apiary
408-644-2382
15325 Uvas Road
Morgan Hill, CA 95037
kingbee@uvasgold.com
www.uvasgold.com

Pure, local, raw artisan honeys, beeswax candles and goat's milk and honey soap.

Find at: Morgan Hill farmers market, Garlic City Mercantile, Patty's Perfect Pantry in Gilroy and Almaden Valley Nursery in San Jose.

FOOD SYSTEM ALLIANCE
SANTA CLARA COUNTY

The Santa Clara County Food System Alliance **(SCCFSA)** is a collaborative of stakeholders concerned with issues of healthy food access, agricultural production, and food distribution in Santa Clara County. The Alliance stimulates synergistic working relationships among individuals and organizations to find creative win-win solutions to problems that impede a more sustainable, effective and accessible food system.

The Santa Clara County Food System Alliance is a project of Ag Innovations Network, a non-profit organization dedicated to helping stakeholders solve problems in the food system through effective collaboration.

For more information visit our website at:
aginnovations.org/alliances/santaclara/

Distributors

Chef's Choice Produce Company
408-213-3880
395 Commercial St.
San Jose, CA 95112
www.chefschoiceproduce.com

Chef's Choice is a local, family owned produce distributor. Serving Northern California with fresh conventional and organic produce for more than 20 years.

Earl's Organic
415-824-7419
San Francisco Wholesale Produce Market, 2101 Jerrold Ave.
San Francisco, CA 94124
katherinev@earlsorganic.com
www.earlsorganic.com

FreshPoint San Francisco
510-476-5900
30340 Whipple Rd.
Union City, CA 94587
www.freshpointsanfrancisco.com

Watsonville Coast Produce, Inc.
800-966-8547
Watsonville, CA 95076
wcpi@coastpro.com
www.coastpro.com

Wholesaler and distributor of conventional and organic fresh fruits and vegetables. If we don't stock it, we can get it. Celebrating 40 years of Gary Manfre buying the business!

Restaurants, Caterers, & Food Service Companies

Baumé Restaurant
650-328-8899
201 S California Ave.
Palo Alto, CA 94306
info@baumerestaurant.com
www.baumerestaurant.com

Baumé specializes in French Modern cuisine using local, fresh produce, with menus that change with the seasons. We serve an eight course tasting menu with the option of three different wine pairings.

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Bon Appétit Management Company

100 Hamilton Ave., Suite 400
Palo Alto, CA 94301
info@bamco.com
www.bamco.com

Bumble

650-383-5340
145 First Street
Los Altos, CA 94022
info@bumblelosaltos.com
www.bumblelosaltos.com

Bumble is a farm-to-fork restaurant in Downtown Los Altos created for locals and families to gather and enjoy a healthy meal and relax with friends over coffee or a glass of wine while children can check in to our bright, sunny playroom. Our menu serves breakfast, lunch, afternoon tea and dinner and changes seasonally to make the most of locally sourced, organic ingredients.

Catered by Diana

408-375-4809
16100 Jacqueline Court
Morgan Hill, CA 95037
chef@cateredbydiana.com
www.cateredbydiana.com

We provide corporate, social and business event catering for all occasions from drop off to full service. Catered by Diana is all about the food! Quality local ingredients prepared especially for our clients while providing a level of service to match.

Country Gourmet

408-733-9446
1314 S Mary Ave.
Sunnyvale, CA 94087
www.country-gourmet.com

Forest on First

650-383-5760
129 First Street
Los Altos, CA 94022
info@forestonfirst.com
www.forestonfirst.com

Forest on First is a play cafe concept for families and friends to come and enjoy each other's company, while munching on delicious, all-natural, locally sourced food. The cafe has a kid-friendly, custom-made Treehouse play structure to keep the little ones entertained. And if you feel like taking the night off from cooking, we offer freshly prepared, complete take-home meals nightly.

Hay Market

408-295-4800
1185 Lincoln Ave.
San Jose, CA 95125
joe@haymarketwillowglen.com
haymarketwillowglen.com

We are "Farm to Table" cuisine specializing in Eclectic Global Comfort Food, and we make our own Bacon and Lardo - while offering a Full Bar, Extensive Wine List, and Craft Beers.

Jesse Cool Restaurants and Catering

650-854-5806
3 restaurants in San Mateo and Santa Clara County, catering serves the larger Bay Area
kathy@cooleatz.com
cooleatz.com

Commited for decades to our local farmers and food producers.

Laura Stec - Innovative Cuisine

650-855-7100
Portola Valley, CA
laura@laurastec.com
www.laurastec.com

Personal and corporate chef. Wellness events and corporate cook classes. Writer/author/speaker with healthy people & planet focus.

My Green Lunch

408-390-6599
326 Commercial St.
San Jose, CA 95112
todd@mygreenlunch.com
www.mygreenlunch.com

My Green Lunch provides healthy, organic, and sustainably sourced meals for Silicon Valley schools and businesses.

Oren's Hummus Catering

650-204-0017
Serving the entire Bay Area
catering@orenshummus.com
www.orenshummus.com

Take advantage of our full service catering to try what we hope you will consider the finest hummus this side of Tel Aviv.

Oren's Hummus Shop

650-752-6492
261 University Ave., 126 Castro St.
Palo Alto, CA 94301, Mountain View, CA 94041
orenshummus@gmail.com
www.orenshummus.com

Oren's Hummus Shop offers authentic Israeli hummus unlike any other hummus you have ever tasted. We are guided by 5 simple principles: authenticity, freshness, health, convenience, and sustainability.

Rock Bottom Brewery

408-377-0707
1875 S. Bascom Ave. #700
Campbell, CA 95008
www.rockbottom.com/locations/campbell

Join us at Rock Bottom Brewery – Campbell's brewery of choice! We offer award-winning handcrafted beer brewed on-site with a diverse menu featuring everything from Cod Fish & Chips to Top Sirloin and refreshing salads.

The Lexington House

408-354-1600
40 N. Santa Cruz Ave. STE A
Los Gatos, CA 95030
thelexingtonhouse@gmail.com
www.thelexlg.com

Bringing together modern Northern California cuisine with classically inspired cocktails, small-batch spirits, craft beer, and limited-production wines, The Lexington House offers a welcoming dining experience for sharing a meal with friends. Opened in September 2013 by Stephen Shelton and Jimmy Marino, the restaurant in Los Gatos, CA, serves a progressive menu dictated by the seasons. Chef Philippe Breneman focuses on ingredients from local, organic, and sustainable farmers, and Shelton and Marino reflect that same philosophy in the bar program they co-curate.

The Table

408-638-7911
1110 Willow St.
San Jose, CA 95125
info@thetablesj.com
www.thetablesj.com

The Table is an urban neighborhood restaurant focused on seasonal ingredients, hand-crafted cocktails and progressive wines. Our cuisine is contemporary American, paying tribute to the people and cultures that call this valley home. We believe that the quality of our product begins at the source—with the farmers, ranchers, and dairymen that produce them.

Wineries & Vineyards

Santa Clara and San Benito counties are home to approximately eighty wineries. While the wineries listed here represent only a handful of all that this wine region has to offer, we look forward to welcoming more as CAFF members in the future!

For more information about local wineries, the new wine trail, and varietals grown in the Santa Clara Valley, visit:
www.santaclarawines.com

For wineries in the Santa Cruz Mountains, visit:
www.scmwa.com

For a directory of wineries in San Benito County, visit:
sanbenitocounty chamber.com/ winery-directory

Aver Family Vineyards

408-203-8575
2900 Soma Way
Gilroy CA 95020
wine@averfamilyvineyards.com
www.averfamilyvineyards.com

Aver Family Vineyards is a magical 8.25-acre vineyard nestled in the beautiful Uvas Valley, at the southern edge of Santa Clara Valley, just south of the Silicon Valley in northern California. Aver Family specializes in the Rhone varietals and blends. We hope that we can share with you an experience you will always remember, and that our wines will remind you that you are part of a family far bigger, yet, much more intimate, than you ever imagined.

Tasting hours: First and third weekend of each month from Noon to 5pm.

Cooper-Garrod Estate Vineyards

408-867-7116
22645 Garrod Road
Saratoga, CA 95070
questions@cgv.com
www.cgv.com

Wine tasting where the grapes are grown, on property farmed by the family since 1893! CSWA Certified Sustainable and CCOF Certified Organic. Picnic tables available; co-located with Garrod Farms Riding Stables.

Tasting hours: Weekends, 11am-5pm Weekdays, Noon-5pm

Creekview Vineyards

408 686-0534
12467 Creekview Ct.
San Martin, CA 95046
info@creekviewvineyards.com
www.creekviewvineyards.com

Family owned and operated, we are a small estate winery nestled along the east foothills of San Martin, California. With a passion for quality, our wines are meticulously hand crafted in small lots to preserve the utmost in character and style.

Tasting hours: Open for tasting Saturday and Sunday 11-5pm every third weekend. Creekview Vineyards wine tasting also offered at Sherman Cellars, 40 Post St. San Jose, CA 95113, 408 288-9463

Guglielmo Winery

408-779-2145
1480 East Main Ave.
Morgan Hill, CA 95037
info@guglielmowinery.com
www.guglielmowinery.com

Located in Morgan Hill, CA, Guglielmo Winery has practiced the fine art of winemaking for three generations. Today, third generation brothers, George, Gene and Gary Guglielmo, offer a family of award-winning Private Reserve varietals and more in the Tasting Room and Gourmet Gift Shop.

Tasting hours: Daily, 10am-5pm, closed major holidays

Lightheart Cellars

408-475-8463
305 Roosevelt Ave.
San Martin, CA 95046
wine@lightheartcellars.com
www.lightheartcellars.com

Lightheart Cellars is a small estate winery in San Martin (Southern Santa Clara County), featuring handmade, single vineyard wines. Bordeaux, Rhone and Burgundy style wines, handmade on the premises by winemakers Jane Mika-Haynie and Sheldon Haynie.

Tasting hours: Open first and third weekends from Noon-5pm or by appointment for private tastings.

Satori Cellars

408-848-5823
2100 Buena Vista Avenue
Gilroy, CA 95020
tom@satoricellars.com
www.satoricellars.com

Satori Cellars believes that great wine and great fruit are inseparable. We believe winemakers create better wines when they are intimately involved in the vineyard and the vineyard caretakers do a better job when they are intimately involved in the winemaking process. The result is a truly handcrafted wine intended to awaken not only your taste buds but your experience of life, your connectedness to the world around you.

Tasting hours: Open for tasting and sales every weekend from Noon-5pm.

Solis Winery

408-847-6306
3920 Hecker Pass Hwy
Gilroy, CA 95020
solis@soliswinery.com
www.soliswinery.com

A working winery dating back to 1917, in 1980, the Vanni family purchased the land and have been producing small-lot, award-winning estate wines ever since. Solis Winery is known primarily for red wines, including: Merlot, Syrah, Sangiovese, and Zinfandel, but also produces perennial gold-medal-winning white varietal Fiano.

Tasting hours: Daily, Noon-5pm

Local Partners & Community Resources

California Native Garden Foundation
www.cngf.org
The California Native Garden Foundation is a non-profit educational, research, and resource organization that promotes gardening with California native plants. Our goal is to increase the popularity and use of California's native plants in the designed landscape.

Collective Roots
www.collectiveroots.org

Committee for Green Foothills
www.greenfoothills.org

Common Ground
commongroundinpaloalto.org
Common Ground provides education and resources to support the local community in growing gardens sustainably through the cultivation of edible and native plants, which facilitate access to fresh nutritious food while maintaining a healthy planet.

Community Links International
www.commlinks.org
Connecting childen and their families to good food and land stewardship through education and immersion.

Deer Hollow Farm
www.mountainview.gov/city_hall/comm_services/recreation_programs_and_services/deer_hollow_farm.asp

Ecological Farming Association
www.eco-farm.org

Edible Silicon Valley
ediblesiliconvalley.com

Emma Prusch Farm Park
www.pruschfarmpark.org

Garden to Table
garden2table.org

Greenbelt Alliance
www.greenbelt.org

Hidden Villa Farm & Wilderness
www.hiddenvilla.org

Hollyhill Hummingbird Farm
hollyhillhummingbird.com

Kitchen Table Advisors
www.kitchentableadvisors.org

La Mesa Verde
www.sacredheartcs.org/our-programs/self-sufficiency/la-mesa-verde

Living Classroom
www.living-classroom.org

Master Gardeners of Santa Clara County
mastergardeners.org/scc.html

Sacred Heart Community Services
www.sacredheartcs.org

Santa Clara County Farm Bureau
www.sccfarmbureau.org

Santa Clara County Food System Alliance
aginnovations.org/alliances/santaclara

Santa Clara County Open Space Authority
www.openspaceauthority.org

Second Harvest Food Bank
www.shfb.org

Slow Food South Bay
slowfoodsouthbay.org
The Slow Food South Bay (SFSB) chapter of Slow Food USA actively promotes our local food communities so that everyone can enjoy food that is good, clean and fair. Encompassing San Mateo and Santa Clara counties, SFSB advocates for food and farm policies, educates about the origins and preparation of real food, and celebrates the region's diverse bounty with visits to farms, restaurants, wineries, and breweries. We are part of the Slow Food network that began in Italy in the 1980s and has grown to more than 150,000 members in more than 150 countries.

Sustainable Agriculture Education - SAGE
www.sagecenter.org

The Health Trust of Silicon Valley
healthtrust.org

UC Small Farm Program
sfp.ucdavis.edu

UC Cooperative Extension Santa Clara County-Nutrition, Family, and Consumer Sciences Program
cesantaclara.ucanr.edu/nutrition

Valley Verde
valleyverde.org

Veggielution
veggielution.org
Veggielution Community Farm's classes and volunteer programs inspire happier and healthier lives while also growing fresh produce for our neighbors in the South Bay that need it most. By cultivating a space where everyone feels included, Veggielution breaks down barriers that keep people apart, uniting South Bay residents across all generations, incomes, and cultures.

Village Harvest
www.villageharvest.org

Weston A. Price Foundation
www.westonaprice.org

Yummy Tummy Farms
yummytummyfarms.com

FOCUS AREAS

- ACCESS
- AG SUPPORT
- EDUCATION
- HEALTH
- PRESERVATION

*Names in BLUE are Buy Fresh Buy Local Members

Join CAFF today!

Complete this form and mail it with payment to the P.O. Box address below. Or sign up to become a member online at *caff.org/support*.

Name ____________________

Farm/ Business ____________________

Street ____________________

City, State, Zip ____________________

Phone Number(s) ____________________

Email ____________________

Website ____________________

Membership Levels

❑ $50 ❑ $250 ❑ $1000
❑ $100 ❑ $500 ❑ $2000
❑ Other $_________

❑ Check #__________
(Payable to CAFF)

❑ Annual membership $_________
❑ Additional donation $_________
TOTAL $_________

❑ Credit Card: ❑ Visa ❑ MC
Card # ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
Exp. Date ___ ___ / 20 ___ ___ CSC# ___ ___ ___
Signature _________________

BUY FRESH BUY LOCAL

When you become a member of CAFF, you are also eligible to receive *Buy Fresh Buy Local* materials for free!

x____

Sign above if you agree to the terms and conditions in the “BFBL Guidelines,” available at www.caff.org/support (or call the CAFF Membership Office at 530.756.8518 x 30).

GROWING FOOD • GROWING FARMS • GROWING COMMUNITIES

P.O. Box 363 • Davis, CA 95617-0363
530.756.8518 (p) • 530.756.7857 (f) • info@caff.org • www.caff.org

Top 10 Reasons to Buy Local

1 BETTER FOR YOU. When fresh fruits and vegetables are locally grown, picked and processed, the vitamins and minerals they contain are at their peak. Fresh produce loses nutrients quickly, and often spends between 7-14 days in transit. In the weeklong (or more) delay from harvest to table, sugars turn to starches, plant cells shrink and produce loses its vitality. Fresh, local produce provides better nutrition and keeps you healthy. In addition, when you know where your food originates, you can choose produce from farmers who use safe growing practices.

2 TASTE AND APPEARANCE. Local farmers can grow tastier varieties if they know they'll be eaten locally and not trucked across the country. Local produce is more delicious because it can be picked at peak ripeness, providing juicy peaches, sweet corn, and bright red tomatoes!

3 SUPPORTS FARM FAMILIES. Since 1935, the U.S. has lost 4.7 million farms. Fewer than one million Americans now claim farming as a primary occupation (less than 1%). And no wonder: farmers today receive less than 10 cents of the retail food dollar. When you buy directly from family farmers at a farmers market, farmstand, or u-pick, your money goes directly to help them continue farming and growing the good food your community needs.

4 PRESERVES GENETIC DIVERSITY. In industrial agriculture, plants are bred for their ability to ripen uniformly, withstand harvesting, survive packing and last a long time on the shelf; therefore there are few varieties in large-scale production. This leaves our food supply vulnerable to disease and disaster. Smaller local farms, in contrast, often grow many different varieties to provide a longer season, an array of colors, and the best flavors.

5 LIGHTER CARBON FOOTPRINT. On average, our food travels 1,500-2,500 miles from the farm to plate. Moreover, each calorie of food produced requires an average of 10 calories of fossil-fuel inputs from travel, refrigeration, and processing. Purchasing locally grown food is a simple way to address the increasing expense of fossil fuels and the adverse effects of global warming from increased carbon emissions. Purchasing locally grown food saves the fuel needed to transport food, reduces air pollution, and combats carbon emissions.

6 PRESERVES OPEN SPACE. As the value of direct-marketed fruits and vegetables increases, selling farmland for development becomes less likely. A well-managed family farm is a place where the resources of fertile soil and clean water are valued. Good stewards of the land grow cover crops that prevent erosion and replace nutrients. In addition, the patchwork of fields, hedgerows, ponds and buildings is the perfect environment for many beloved species of wildlife. When you buy locally grown food, you are helping to preserve the agricultural landscape.

7 BUILDS TRUST. In today's society there are many issues that surround food, including food safety. There is an assurance that comes from directly speaking with growers at the farmers market, or driving by the fields where your food comes from.

8 LOCAL ECONOMIC STRENGTH. Buying local food also keeps your dollars in the community, providing jobs and creating a more healthy and vibrant local economy. Every dollar you spend with a local family farmer circulates through the community 7 to 11 times, multiplying the benefit of that dollar for everyone.

9 BUILDS COMMUNITY. When you buy directly from a local farmer, you're engaging in a time-honored connection between consumer and grower in addition to supporting a local business. Learning who grows your food teaches you about where you live. In many cases, it also gives you access to a place where you can go to enjoy natural habitats and to learn more about how food is grown.

10 INVESTMENT IN OUR FUTURE. By supporting local growers today, you can help ensure that there will be farms in your community tomorrow, and that future generations will have access to nourishing, flavorful, and abundant food.

Use this guide to find out what's in season, read about local farmers, find a farmers market or CSA near you, and plug into your vibrant local food scene.

Do you want you local business to support local farmers? Slip comment cards in with your check or stuff them in suggestion boxes. Contact your local CAFF office for copies of the comment card, or print your own at:

tinyurl.com/n4h8z57

Vote with your dollar & your fork & your voice!

Adapted from Massachusetts Department of Agricultural Resources and ©2001 Growing for Market

Presentations for 12 BMP
2012 - 2015

Presentation	Location	Date	Presenter	Size of Audience	TradeShow Visits
Monsanto Update	St. Louis, MO	26-Oct-12	CH	10	
CA State Beekeepers Assoc	Cabazon, CA	14-Nov-12	CH	50	250
CA Spec Crop Council	Sacramento, CA	7-Dec-12	CH	25	
Almond Board of CA	Sacramento, CA	13-Dec-12	CH	200	2400
American Honey Producers	San Diego, CA	9-Jan-13	HR	100	300
American Beekeeping Fed	Hershey, PA	10-Jan-13	CH	75	750
CAPCA	Chico, CA	10-Jan-13	F Thomas	60	
CA Farm Bureau	Sacramento, CA	23-Jan-13	CH	25	
Delta Bee Club	Modesto, CA	5-Mar-13	CH	60	60
Mt. Diablo Beekeepers	Walnut Creek, CA	14-Mar-13	J Miller	280	280
CDFA Site Visit	Chico, CA	26-Apr-13	CH	4	
Central Valley Beekeepers	Fresno, CA	9-May-13	HR	30	30
Honey Bee Health Summit	St. Louis, MO	1-Jun-13	CH	125	125
Orange County Beekeepers	Orange County, CA	4-Jun-13	HR	40	40
Colorado State Beekeepers	Silt, CO	15-Jun-13	CH	85	85
America's Grasslands	Manhatten, KS	15-Jun-13	CH	30	100
Penn State Univ (Poster)	State College, PA	16-Aug-13	CH	0	150
North Dakota Beekeepers	Mandan, ND	11-Oct-13	CH	60	60
Western Apiculture Society	Santa Fe, NM	18-Oct-13	GW	50	100
Delta Bee Club	Modesto, CA	1-Nov-13	D Qualls	50	50
Oregon State Beekeepers	Seaside, OR	2-Nov-13	HR	50	100
CA Farm Bureau Fed Forage	Sacramento, CA	6-Nov-13	CH	30	30
Entomological Soc of Amer	Austin, TX	12-Nov-13	CH	50	
California State Beekeepers	S. Lake Tahoe, CA	19-Nov-13	CH, GW	100	400
Almond Board of CA	Sacramento, CA	5-Dec-13	CH	400	2500
Idaho Honey Industry Assoc	Boise, ID	6-Dec-13	HR	75	100
American Beekeeping Fed	Baton Rouge, LA	9-Jan-13	HR	100	500
American Honey Producers	San Antonio, TX	9-Jan-14	CH	85	300
Southwest Ag Summit	Yuma, AZ	27-Feb-14	CH	60	
Mt. Diablo Beekeepers	Walnut Creek, CA	12-Jun-14	CH	250	250
CDFA Site Visit (12 Forage)	Davis, CA	17-Jul-14	CH	4	
CDFA On-Site Visit (12 BMP)	Shafter, CA	31-Jul-14	CH	4	
Inter Tribal Council of AZ	Chandler, AZ	27-Aug-14	CH	100	
North Dakota Beekeepers	Mandan, ND	1-Oct-14	GW	60	60
Florida State Beekeepers	Palm Beach, FL	3-Oct-14	GW	75	

Presentations for 12 BMP
2012 - 2015

Montana State Beekeepers	Lewistown, MT	16-Oct-14	CH	35	50
USDA Forage/Nutrition Summit	Alexandria, VA	20-Oct-14	CH	200	
California State Beekeepers	Valencia, CA	18-Nov-14	CH	150	400
Wyoming Beekeepers	Wyoming	1-Dec-14	P Heitkam	30	40
Idaho Honey Industry Assoc	Boise, ID	4-Dec-14	CH	75	100
Almond Board of CA	Sacramento, CA	11-Dec-14	CH	400	2500
American Beekeeping Fed	Anaheim, CA	8-Jan-15	CH	100	500
Central Valley Beekeepers	Central Valley, CA	17-Jan-15	G Brandi	40	40
Amer Bee Research Conf	Tucson, AZ	23-Jan-15	CH	50	
Total:				**3882**	**12650**
Grand Total:					**16532**
Presenters: Christi Heintz (CH); Gordon Wardell (GW); Hannah Ribotto (HR)					

Sonoma County Winegrape Commission

CDFA Specialty Crop Block Grant Review

Project 13 Title: Branding Sonoma County Wines

Abstract: Sonoma County wines draw solid price premiums due to their quality and research shows 68% of wine consumers associate Sonoma with quality wine. All Sonoma American Viticulture Area (AVA) labels were recently required to include "Sonoma County," providing a unique chance to market and promote this highly valued name uniformly, and to build brand value for Sonoma County wines. This will be accomplished by local/regional/national promotional events, online & print ads, create an online wine locator for consumers to locate and purchase wines direct, and conduct on/off sale programs.

Grant Funding: $378,881

cdfa

Sonoma County
WINEGRAPE COMMISSION

1. Sonoma County Winefinder

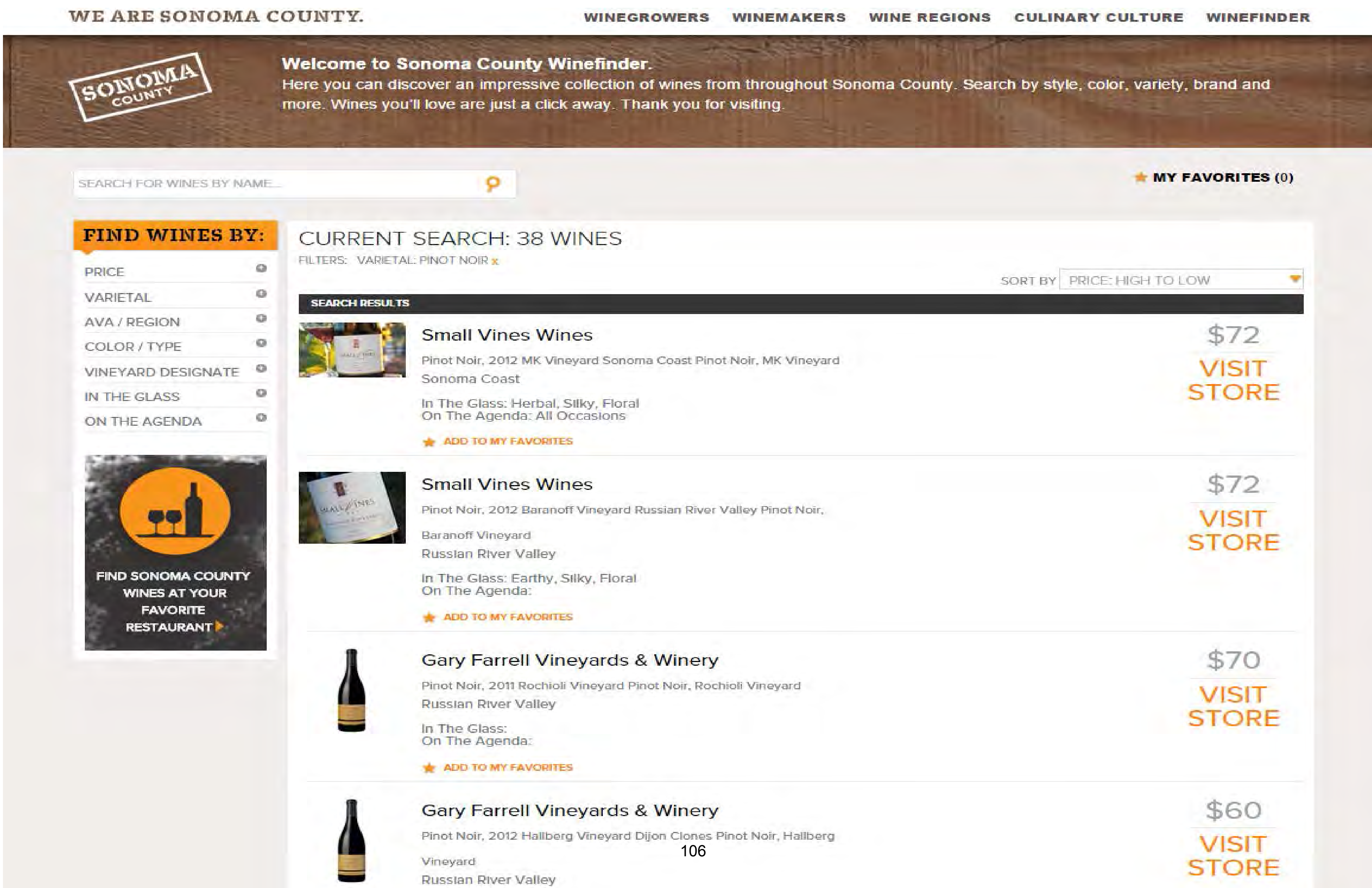
Goal: Create an online database of Sonoma County wines to help consumers search out and find wines to purchase online.

Project Details: In partnership with Sonoma County Vintners and Sonoma County Tourism, with technical assistance by Asterix Group, we developed, designed, and built out an online portal that allows consumers to search for their favorite Sonoma County wines based of personal preferences, such as varietal, style, price, AVA, occasion, vineyard, and more.

SONOMA COUNTY WINEGROWERS

Sonoma County Winefinder

Sonoma County Winefinder



Sonoma County Winefinder

Results to date:

- Launched in early 2015
- In the first 2 months of the launch, Winefinder was the most visited section of WeAreSonomaCounty.com
- More than 250 SKU's of Sonoma County wines entered into system…and counting.
- Digital campaign coming soon…

2. Food & Wine Magazine

Project Details: A multi-year, national advertising and promotional campaign with Food & Wine Magazine, which is one of the most widely read epicurean and wine magazines in the world. This includes:

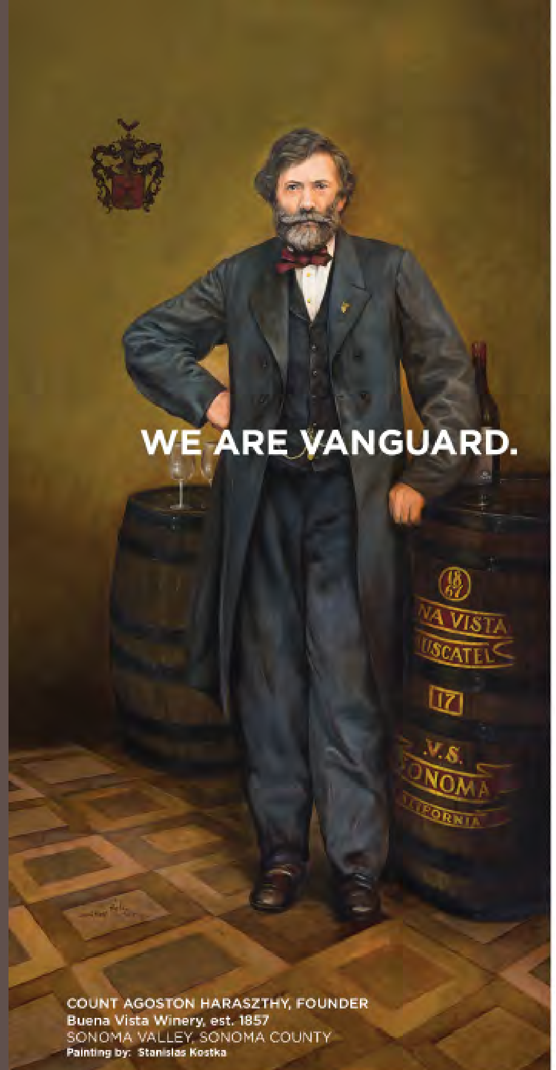
- **Print Advertising: Purchased 3-6 full page print ads that reached 8 million readers every month.**
- **Events:**
  - **Participated at the Food & Wine Aspen Classic in 2013 & 2014, reaching more than 5,000 consumers and influential wine trade.**
  - **Participated at 2013 Food & Wine Pebble Beach, reaching 1,000 consumers, influential wine trade, and others.**
- **Collaboration: Worked with Sonoma County Tourism, Sonoma Valley Winegrowers and Vintners Alliance, Winegrowers of Dry Creek Valley, etc.**

FOOD & WINE MAGAZINE

SONOMA COUNTY WINEGROWERS


WE ARE KNOTTY.
WE ARE NICE.
KUNDE FAMILY ESTATE, PLANTED IN 1882
Sonoma Valley
SONOMA COUNTY
HALLBERG VINEYARD, PLANTED IN 2000
Green Valley of the Russian River Valley
SONOMA COUNTY
WE ARE SONOMA COUNTY.
By some cosmic act of great fortune, Sonoma County won the geological lottery. The distinctive microclimates, the grape-intensifying soil, the morning coastal fog, the redwoods and mountains that tumble down to the Pacific. This is the epicenter of wine, and boy, are we glad to be here. Around every bend there's a new discovery and an unforgettable wine. The knotty part? You show up at the last winery at 3:59 – right before closing. But then we say, "Come on in, we're pouring the Reserve Chard." How nice is that?
WeAreSonomaCounty.com
SONOMA
COUNTY


&WINE
grilling ideas
76 sizzling recipes
20 fast sauces + salsas
10 smart tips
for easy grilling
ultimate
summer
wine
guide



WE ARE SONOMA COUNTY.

It all started in Sonoma County back in 1857. Guess that makes us early pioneers, but the vision is always about the next vintage. Over a century later, that sense of anticipation and discovery is something our winemakers aim to capture, bottle and cork. It might be a classic Old Vine Zin or a daring Pinot Noir from a couple of local boys. Critical acclaim, innovation and cutting edge technology are truly exciting, but perhaps like you, our first reaction is a bit more pragmatic — Where's the corkscrew?

WeAreSonomaCounty.com

SONOMA COUNTY


WE ARE FOR HERE.
SARAH QUIDER, Ferrari-Carano Vineyards & Winery
KEVIN HALL, Alexander Valley Vineyards
RICK SAYRE, Rodney Strong Vineyards
STEVE MACROSTIE, MacRostie Winery & Vineyards
JOE FREEMAN, River Road Family Vineyards & Winery
(clockwise, from left)


WE ARE TO GO.
RIVER ROAD
FERRARI-CARANO
Chardonnay
MACROSTIE
RODNEY STRONG
Sin Zin
ZINFANDEL
MACROSTIE WINERY & VINEYARDS, Sonoma Coast
RIVER ROAD FAMILY VINEYARDS & WINERY, Russian River Valley
FERRARI-CARANO VINEYARDS & WINERY, Dry Creek Valley
ALEXANDER VALLEY VINEYARDS, Alexander Valley
RODNEY STRONG VINEYARDS, Russian River Valley
(clockwise, from left)

WINEGROWERS OF DRY CREEK VALLEY · 1870 · SONOMA COUNTY

SONOMA VALLEY WINE EST. 1857


PEBBLE BEACH
FOOD&WINE
PRESENTED BY FOOD&WINE


FOOD&WINE
classic in aspen
GLASS RETURN

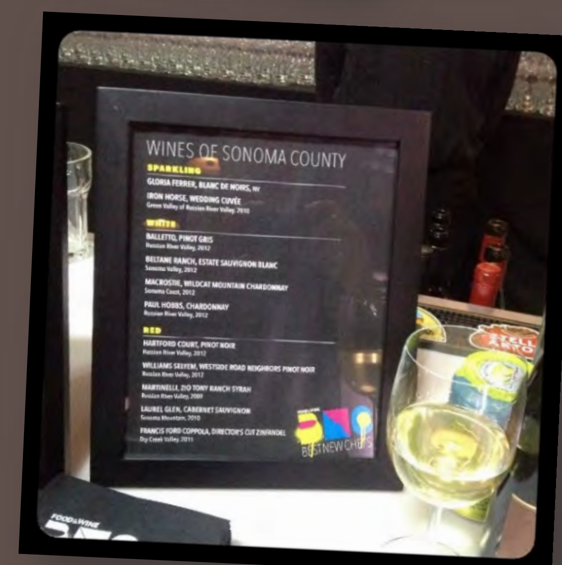

La Crema
Jackson Estates
RODNEY STRONG

Sonoma County FEATURED AT


STUPAK


OLICCHIO
EXIT
TOM COLICCHIO


FOOD&WINE
SONOMA COUNTY
STELLA ARTOIS BELGIUM
S.PELLEGRINO
All-Clad
TWININGS


WINES OF SONOMA COUNTY
SPARKLING
GLORIA FERRER, BLANC DE NOIRS, NV
IRON HORSE, WEDDING CUVÉE
Green Valley of Russian River Valley, 2010
WHITE
BALLETTO, PINOT GRIS
Russian River Valley, 2012
BELTANE RANCH, ESTATE SAUVIGNON BLANC
Sonoma Valley, 2012
MACROSTIE, WILDCAT MOUNTAIN CHARDONNAY
Sonoma Coast, 2012
PAUL HOBBS, CHARDONNAY
Russian River Valley, 2012
RED
HARTFORD COURT, PINOT NOIR
Russian River Valley, 2012
WILLIAMS SELYEM, WESTSIDE ROAD NEIGHBORS PINOT NOIR
Russian River Valley, 2012
MARTINELLI, ZIO TONY RANCH SYRAH
Russian River Valley, 2009
LAUREL GLEN, CABERNET SAUVIGNON
Sonoma Mountain, 2010
FRANCIS FORD COPPOLA, DIRECTOR'S CUT ZINFANDEL
Dry Creek Valley, 2011
BEST NEW CHEFS

FOOD & Wine Partnership

Results to date:

- Very Strong Partnership with this influential epicurean and wine media company.
- Reached 100+ Million Readers over the span of the promotion.
- Poured 100+ wines to thousands of consumers and influential wine trade (sommeliers, chefs, distributors, restaurateurs, etc) at events.
- Offered exclusive opportunities to participate at signature Food & Wine events, including 2014 Best New Chefs.
- Developing long term partnership

3. Target Market Advertising

Project Details: Comprehensive advertising campaign to promote Sonoma County winegrowers and wines to consumers in target wine markets to build awareness of Sonoma County wines, drive purchase at local wine retailers and restaurants, and increase consumer attendance at local Sonoma County events.

SONOMA COUNTY WINEGROWERS

Target Market Advertising

Wine Spectator
www.winespectator.com

THE WALL STREET JOURNAL.

WINE ENTHUSIAST
MAGAZINE

San Francisco Chronicle

Sonoma Index-Tribune

Horizon EDITION
MAGAZINE

USA TODAY Travel

sonoma
magazine

NORTH BAY
BOHEMIAN

THE WINDSOR TIMES

THE PRESS DEMOCRAT


WE ARE DOWN HOME.
GREG STACH, Landmark Vineyards
AARON PIOTTER, Ferrari-Carano Vineyards & Winery
JOE FREEMAN, River Road Family Vineyards and Winery
GREG MORTHOLE, Davis Bynum Winery
KATHLEEN INMAN, Inman Family Wines
(clockwise, from left)


WE ARE UPTOWN.
INMAN
RIVER ROAD
LANDMARK VINEYARDS, Sonoma Coast
INMAN FAMILY WINES, Russian River Valley
FERRARI-CARANO VINEYARDS & WINERY, Alexander Valley
DAVIS BYNUM WINERY, Russian River Valley
RIVER ROAD FAMILY VINEYARDS AND WINERY, Russian River Valley
(from left to right)

Special Advertising Section

Special Advertising Section

Finding the Fork in the Road

Sonoma County's vines, views and locally-sourced cuisine stand out in these less-traveled road trips

By Barbara A. Noe

While some travelers are content to stick to a tourist itinerary, an increasing number can't resist "the road not taken" — the hidden back roads and undiscovered experiences that turn a trip into something truly memorable. It's less about the race to knock things off a "must-see" checklist, and more about what you can do and who you may meet along the way.

Almost everywhere along Sonoma County's 1,283 miles of scenic country roads there's something stop-worthy — and much of it is only about an hour from San Francisco. There are storybook views, inventive farm-to-table cuisine, people with colorful stories to share and off-the-path activities that you rarely hear about.

At the center of it all are Sonoma County's world renowned wines — 16 distinct appellations, with 450 small and family-owned wineries and more than 1,800 winegrowers ready to put out the welcome mat. To make the most of your time, these three itineraries showcase some of the region's most memorable and less-traveled adventures.

Start Planning Your Trip

Trip 1 Going Coastal

Begin this stunning sea-and-vineyard loop in Petaluma, just 45 minutes north of San Francisco. Get your morning kick-start at Della Fattoria bakery and cafe or Hallie's Diner, where you can fill up on a fresh and locally-sourced breakfast before you buckle your seatbelt and head off toward the coast.

About 30 minutes away is Bodega Bay, where Alfred Hitchcock filmed *The Birds* in 1963 — though these days it's better known for its craggy beaches, art galleries and 300-boat-strong fishing fleet. For lunch, dig into creamy clam chowder from Spud Point Crab Company, a seafood shack with picnic tables overlooking the bay, or stop in at Michelin-starred Terrapin Creek Café.

Heading up the wild coast along Highway 1 is tiny Jenner, where the Russian River spills into the sea and large rock formations dot the shoreline of Goat Rock Beach. Get up close to a colony of resident harbor seals (you can view them from just 50 yards away) or watch the spectacular seasonal migration of the California gray whales. Farther north at Fort Ross Vineyard, Sonoma County's westernmost winery located in the newly established Fort Ross-Seaview AVA, you can stop in and sample some bold Pinot Noirs and Chardonnays. The wines are almost — but not quite — outdone by the ocean views from the vineyard's two-story deck.

Follow the Bohemian Highway through sky-high redwoods to Occidental, where you'll bump shoulders with artists, vintners, hikers and cyclists along the two-block main street. If it's Friday, they're probably headed to the farmers market. If you've got the time, relax in a fragrant cedar enzyme bath at Osmosis, a Japanese-style spa in Freestone, or take a walk in its meditation garden, a mesmerizing labyrinth of stone, plants and water.

In Green Valley, a subregion of the Russian River Valley AVA, cool-climate Pinot Noirs and Chardonnays thrive. You've got your pick of wineries that work with grapes from the region's most extreme vineyards, including Red Car Wine Co., Dutton-Goldfield, and, east of town, Lynmar Estate. Take a moment to do something special: Grab your glass of wine from the tasting bar and stroll amid the vineyard rows. Standing there, surrounded by the green-gold vineyard views as far as the eye can see, you'll feel a deep-rooted connection to the land and a true sense of where wine begins.

In fact, everywhere you go, you are reminded that sustainable agriculture, whether for wine or produce, is deeply entrenched in the lifestyle of Sonoma County. The multigenerational family winegrowers are focused on having all of the 59,000 acres in the county farmed sustainably by 2019, a natural progression for a region with a legacy of preserving the land and agriculture.

Another crop — apples (Gravensteins in particular) — built Sebastopol, although today the town buzzes with an artsy energy. Your first stop here must be The Barlow, the funky new culinary and arts center occupying the grounds of an old apple-processing plant. You'll find several artisan wineries here, including La Follette and MacPhail, along with Freeman Vineyard and Winery, all specializing in Pinot Noir and Chardonnay from the best vineyard sources. Celebrity chef Duskie Estes's Zazu Kitchen & Farm, priding itself on its "snout to tail" cooking, is *the* place for lunch or dinner.


Trail with a view

Trip 2 Gateway to Wine Country

The towns of Sonoma and Glen Ellen are huddled in the heart of Sonoma Wine Country and they're the perfect starting point for your next adventure. Grape growing and winemaking are crafts passed down from parent to child in Sonoma County, and a host of multigenerational family wineries and vineyards surround the towns. Two local favorites are Gundlach Bundschu, California's oldest continuously family-owned winery, going into its sixth generation, and Patz & Hall, in its new Sonoma House venue just north of Sonoma's Eighth Street wineries. Schug Carneros Estate is one of eight different wineries that are part of Sonoma County Vineyard Adventures, which offers free, self-guided vineyard tours and tastings where you can experience the art of the winegrower and sustainable farming in action.

Busy Sonoma is surely not on the road less traveled, but no trip would be complete without a visit to its central plaza and the many great shops, galleries, tasting rooms, cafes and restaurants awaiting discovery. Harvest Moon Café and La Salette are two of the newer dining stand-outs. As you'll find with almost all restaurants in the region, the food is seasonal and locally sourced with many of the ingredients actually farmed by the staff.

Just up the road via Highway 12 and down Arnold Drive, Glen Ellen looks every bit like it did when Bohemian adventurer Jack London first arrived in 1909. These days, the town's 19th-century brick buildings hold trendy establishments, including Glen Ellen Star, getting noticed for its rustic-chic menu (Chef Ari Weiswasser's French Laundry background comes through in menu items like juicy lamb meatballs in red charmoula) and Gaige House, an understated, vintage-luxe inn. Pop into Korbin Kameron Winery's tasting room right across the street for beautiful Cabernet Sauvignon and other reds. Just outside town is Jack London State Historic Park, where you can tackle the 8.25-mile round-trip hike up Sonoma Mountain for amazing Valley of the Moon panoramas of wine country.


Take a vineyard walk

A free visitors guide and map are available from Sonoma County Tourism at sonomacounty.com

Additional resources:
- SonomaVineyardAdventures.com
- SonomaWineCountryWeekend.com
- SonomaCountyGrapeCamp.com

Learn more: WeAreSonomaCounty.com

Trip 3 Across Creek and Valley

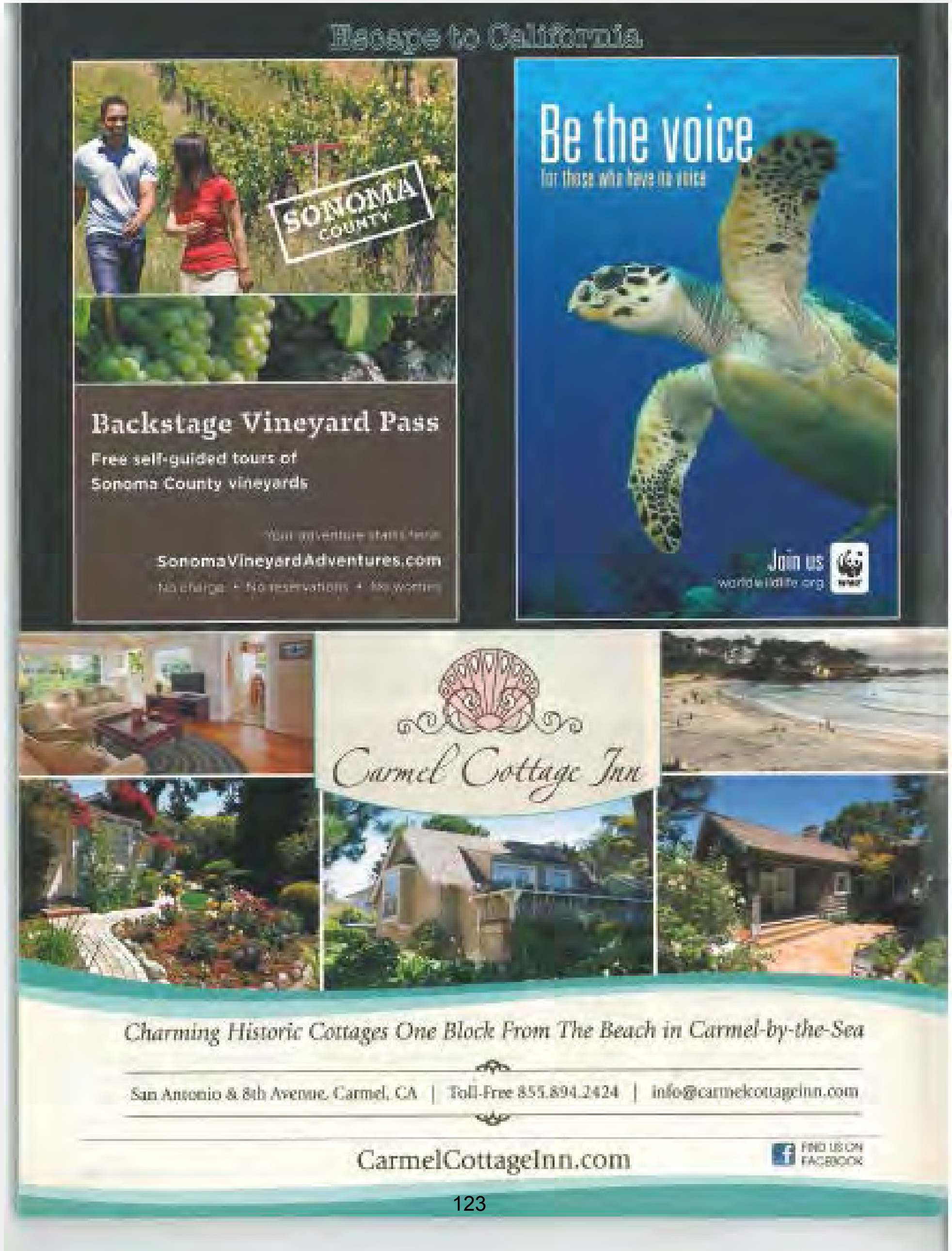
The world knows Northern California for its award-winning wines, but for some people Alexander Valley and Dry Creek Valley are still flying under the radar, making them a bit of a best-kept secret. Begin your exploration by stocking up at Jimtown Store, a country market and gathering place just north of Healdsburg, then drive into Alexander Valley, where vineyards mingle with the occasional horse ranch, orchards and groves of oak trees. Don't miss farmhouse-chic Medlock Ames — the sort of place you don't want to tell anyone about for fear of word getting out — or Garden Creek Vineyards, which offers candlelit wine tastings in the barrel room by appointment.

Next, take Canyon Road over to sweet little Dry Creek Valley, its hairpin turns taking you through colorful fields of honeysuckle and wild berries. You can make a pretty loop via West Dry Creek Road and Dry Creek Road — perhaps the most popular cycling loop the region has to offer. Top stops include Dry Creek Vineyard, whose flowering magnolia has got to be the most sublime picnic perch around; Lambert Bridge, with a warm-feeling tasting room and lovely gardens; and Mounts Family Wines, where second and third generation family members will charm you with stories about growing up among the vineyards and farming grapes over the past half century.

At the end of the day, unwind in Healdsburg, northern Sonoma's wine and food epicenter. On a warm evening, there's nothing better than strolling around the Spanish-style plaza, poking into hip tasting rooms and boutiques. You have tons of innovative restaurants to choose from. Two of the newer options are Campo Fino, a second restaurant run by the owners of the always-packed Scopa, and Bravas, offering a stylish wine-country take on tapas.

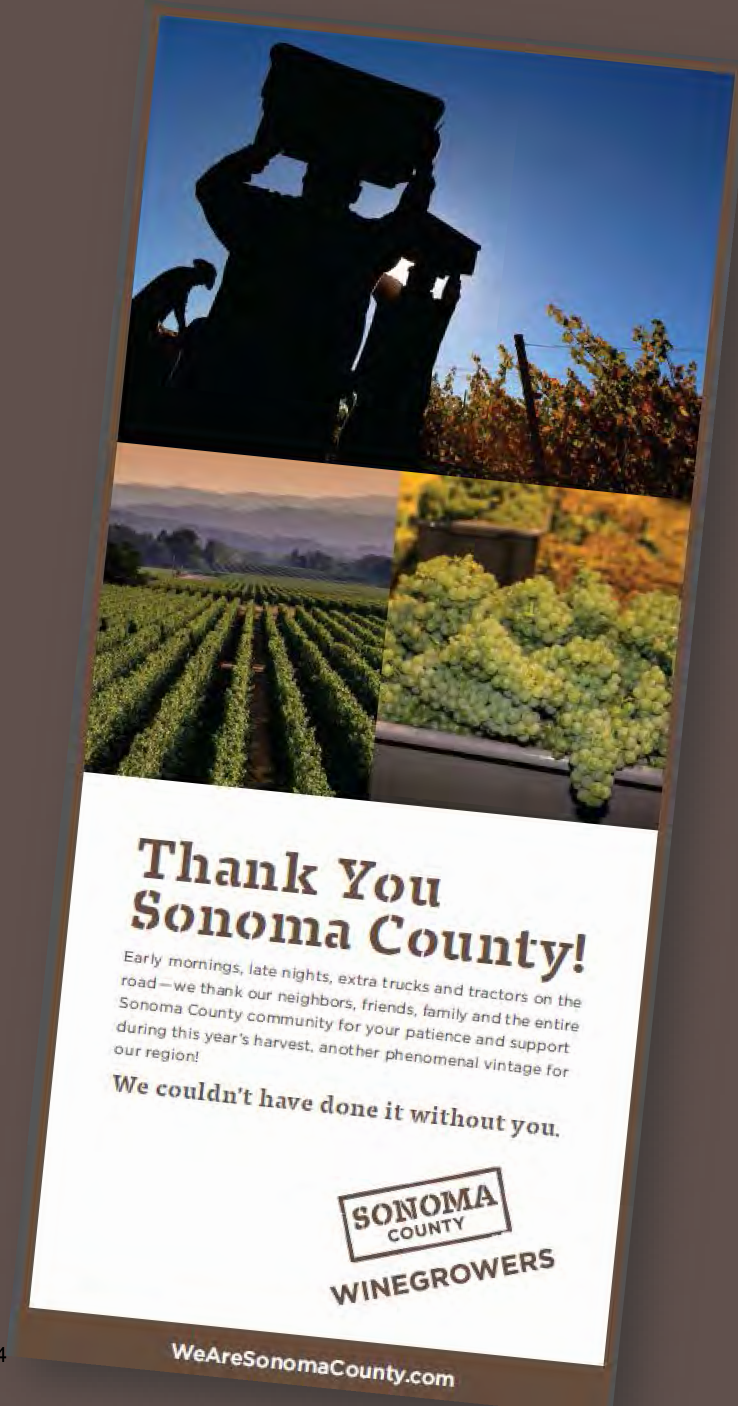
To get a genuine feel for Sonoma County, you've got to hit the road. Sometimes a dirt road takes you to a tucked-away vineyard or winery, or a hiking trail leads you to a canopy of redwoods. Sometimes that road is a paved highway that takes you to towns filled with offbeat shops, tasting rooms and imaginative, organic cuisine. Wherever you travel in Sonoma County, just remember to keep an eye out and your camera ready — there's always something new to discover around the bend.


The Ultimate Fantasy Camp for Wine Lovers
SONOMA COUNTY
GRAPE CAMP
SEPTEMBER 21-23, 2015
• Work in spectacular vineyards
• Blend world-class wine
• Savor farm fresh food
• Enjoy luxurious accommodations
• Relish the stories of our growers, winemakers and chefs
Reserve Now, Space is Limited
www.sonomagrapecamp.com/SWCW
707-522-5864



SONOMA COUNTY WINEGROWERS


Congratulations to our top four winners: (left to right) Juan Carlos Alvarenga, Redwood Empire Vineyard Management, Alexander Valley (4th place); Juan Antonio Lopez, Bevill Vineyard Management, Dry Creek Valley (3rd place); Luis Ortiz, Viña Pro Vineyard Management, Alexander Valley (2nd place); and Rosalio Saucedo Solorio, Seghesio Family Vineyards, Alexander Valley (1st Place).
Photography by Van Cleemput Photography
¡Muchas felicidades!
Ganadores del campeonato de poda del condado de Sonoma 2014
El 7 de marzo, la comunidad vinícola del condado de Sonoma se dio cita para festejar a nuestros trabajadores vinícolas por todo lo que hacen para mantener nuestros viñedos saludables. Nada es más importante que el arte de la poda de viñedos, el cual permite crear las condiciones adecuadas para las uvas cultivadas y producir vinos de calidad en cada cosecha. La impresionante demostración de velocidad, precisión y exactitud de los ganadores del Campeonato de Poda es un ejemplo perfecto de nuestro talentoso equipo de trabajo—quienes representan la columna vertebral de la industria vinícola del condado de Sonoma.
Agradecemos a todos ustedes, los trabajadores de nuestros viñedos, todas sus habilidades, dedicación y contribuciones infinitas que han hecho del condado de Sonoma una de las regiones productoras de vino líderes de todo el mundo. Desde el podar durante los fríos inviernos hasta el cosechar antes del amanecer durante el otoño, realmente ¡no pudiéramos lograr todo esto sin ustedes!
Congratulations!
2014 Sonoma County Pruning Championship Winners
On March 7, the Sonoma County winegrowing community gathered to celebrate our vineyard workers for everything they do to keep our vines healthy. Nothing is more significant than the craft of vine pruning that sets the stage for quality wine grapes every vintage. The Pruning Championship winners' impressive display of speed, precision and accuracy is a perfect example of our talented workforce—the backbone of Sonoma County's wine industry.
We appreciate all of you, our vineyard workers, for your skill, dedication and endless contributions toward making Sonoma County one of the leading wine producing regions in the world. From pruning in the cold of winter to harvesting before sunrise in the fall, we couldn't do it without you!
SONOMA COUNTY WINEGROWERS
PLATINUM SPONSORS
BAHCO Pruning Tools
INFACO
SANTA ROSA JUNIOR COLLEGE
CHRIS MALONEY CROP INSURANCE SERVICES
GOLD SPONSORS
BEVILL
Tri Valley
CENTRAL VALLEY AGRICULTURE SUPPLY
Redwood Empire Vineyard Management, Inc
SunRidge Nurseries
SonomaWinegrape.org


Thank You Sonoma County!
Early mornings, late nights, extra trucks and tractors on the road—we thank our neighbors, friends, family and the entire Sonoma County community for your patience and support during this year's harvest, another phenomenal vintage for our region!
We couldn't have done it without you.
SONOMA COUNTY WINEGROWERS
WeAreSonomaCounty.com

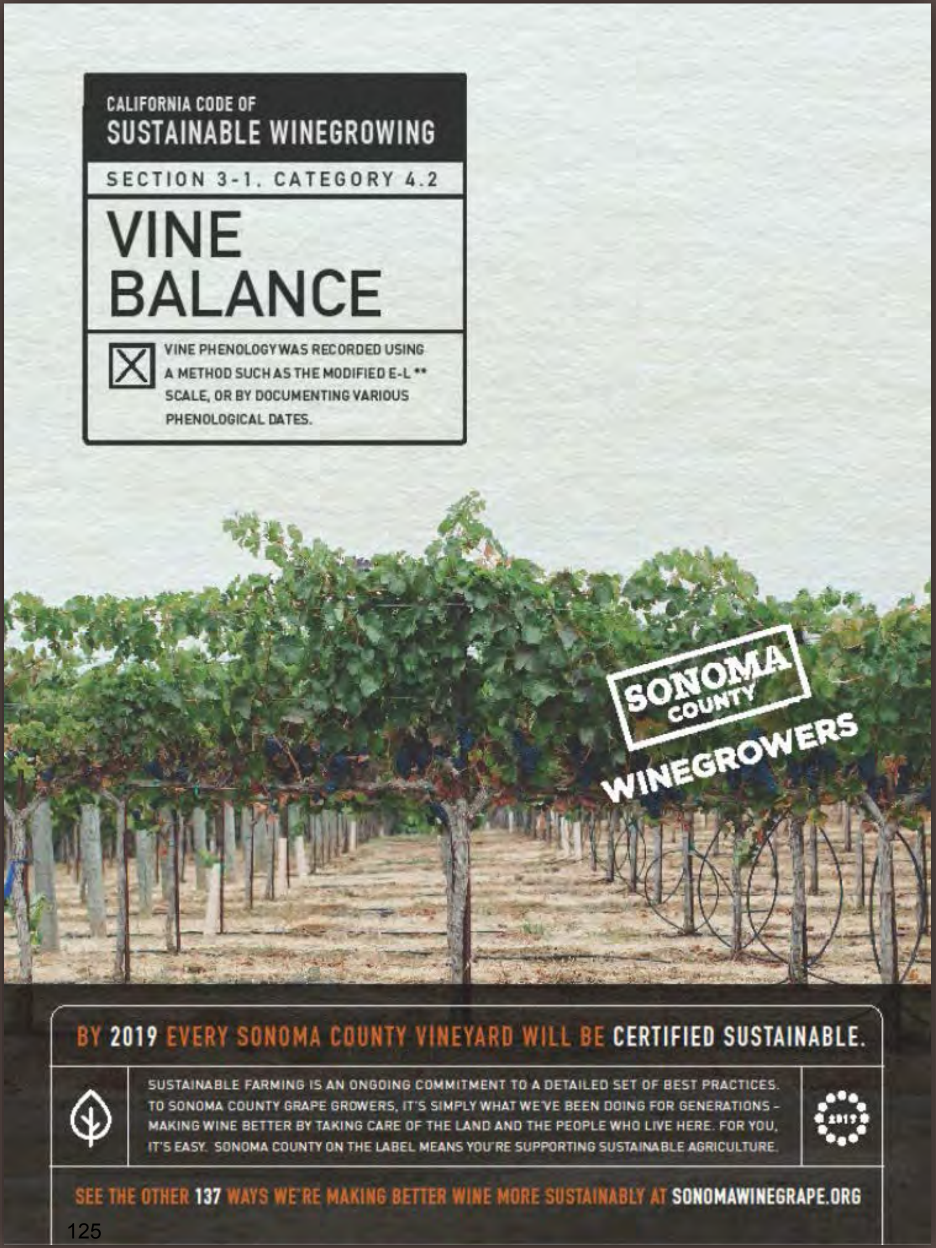
FOOD&WINE MAGAZINE

Wine Spectator www.winespectator.com

WINE ENTHUSIAST MAGAZINE

San Francisco Chronicle

SONOMA SONOMANEWS.COM SONOMAMAG.COM



Target Market Advertising

Results to date:

- Increased awareness and branding for Sonoma County Winegrowers and wines.
- Purchased print advertising in 15+ different publications with a national, regional, and local consumer reach.
- Combined readership of more than 50 Million across the U.S.
- Sold out our annual Grape Camp consumer harvest and winemaking experience months in advance and we continue to have a waiting list for 2015.

3. Grape Trade Advertising

Project Details: Purchased a series of print ads in vineyard and winery trade publications to increase awareness of the quality of Sonoma County grapes, as well as increase sales and value of grapes in the region. The print ads were also intended to support our Grape Marketplace, an online portal allowing grape growers to sell their winegrapes.

Vineyard & Winery Management Magazine
North America's leading *independent* wine trade magazine

PW PRACTICAL Winery & Vineyard

Unified WINE & GRAPE SYMPOSIUM
PRESENTED BY ASEV & CAWG

WINE BUSINESS MONTHLY
The Industry's Leading Publication for Wineries and Growers

WINES & VINES

WE ARE SONOMA COUNTY.

As growers, our goal is to offer grapes in as many varieties as our wineries need, and in quantities large and small. It tickles us pink (and deep red, bright green and golden yellow) to do it all. We suppose this might be what's put our grapes in the limelight for over 155 years. Or maybe it's the relationships we've built with creators of artisan and widely recognized brands alike who rely on us as their trusted resource for quality and quantity. Either way, we don't need to be the center of attention - come to us, do what you do best, and then... the spotlight's on you.

SONOMA COUNTY WINEGROWERS

Find your grapes here – sonomawinegrape.org/marketplace

Grape Trade Advertising

Results to date:

- Increased awareness and branding for Sonoma County Winegrowers.
- Sonoma County grape growers have been shown as leaders in agriculture, sustainability, and quality sources of winegrapes.
- Grape pricing has increased year-over-year and demand is on the rise.

4. On/Off Premise Sales Promotion

Project Details: Create an on/off premise sales promotion with a retailer or restaurant partner to introduce customers to Sonoma County wines, drive purchase or trial through special pricing, promotional point of sale materials, and in-store education.

BINNY'S RETAIL PARTNERSHIP
March 1-31, 2015

31 Stores Throughout Chicago Metro Area

Staff Trainings
In-Store Tastings for Consumers
Sonoma County Branding & Point of Sale Material
End Cap Displays
Special Sales and Discounts on Sonoma County Wines
Promotion focused on Grape Growing Practices & Sustainable Farming

MARCH 3rd IN-STORE WINEMAKER TASTINGS

4 Store Promotion in Chicago Metro Area
17 Winemakers & Winegrowers

Binny's Beverage Depot

SONOMA COUNTY WINEGROWERS

On/Off Premise Partnership

Branding Results:

- Retail partnership built on already successful Sonoma in the City Chicago promotion to wine trade, media, and consumers.
- Increased branding and awareness of Sonoma County in all 31 stores throughout Chicago metro area.

On/Off Premise Partnership

Sales Results:

- 7% volume increase for Sonoma County category
- 10% revenue increase for for Sonoma County wines
- Out of 58 featured wines, there was a 34% growth in volume sold, along with a 33% increase in revenue for March 2015, compared to same period in 2014.

THANK YOU!

CalAgX
YOUR WORLD. YOUR MARKET.

This April, CDFA will be jointly hosting CALAGX 2015 – the only comprehensive export training program available to California's specialty crop growers. The program provides intensive training to help companies move their products into foreign markets, led by instructors who are experts in the fields of banking/finance, shipping/logistics and sales & marketing.

"The CalAgX Training Program assisted our company by helping us better understand and respond to foreign sales inquiries, as well as navigate foreign market requirements," said Gold River Orchards President Don Barton, a past participant of the training program. "We've seen success with this program and it has been very useful for our company."

The 2015 California Agricultural Export Training (CalAgX) Program is a six session seminar program held over a two month period and focuses on issues such as finance, export documentation, market barriers and federal/state resources. More than 300 companies have taken CalAgX since its inception in 2005 and past participants have included Blue Diamond Growers, Earthbound Farm, Harris Fresh, Morning Star Packing Company, National Raisins, Point Conception Wines, Ratto Bros, and Summit Almonds.


Participants in a recent CalAgX Training

"Interest in international trade continues to grow", said Alicia Rios with the State Center Community College District. The District, part of the statewide Center's for International Trade Development, are the organizers of the training program. "As incomes rise in foreign markets, California's specialty crops are increasingly in demand among the world's consumers. We are seeing a lot of specialized food companies taking advantage of these international opportunities."

Applications are now being accepted through April 10, 2015. Training will be held in Salinas, Fresno and Sacramento and classes begin the week of April 13th. For more information, please visit www.fresnocitd.org or call 559.324.6401.

The CalAgX program is hosted by the California Center for International Trade Development at State Center Community College District, and is funded by the 2012 Specialty Crop Block Grant program of the United States Department of Agriculture, and is presented by the California Centers for International Trade Development in cooperation with the California Department of Food and Agriculture

Share this: Like 0 Tweet 0 Share Share 0 Email

This entry was posted in Agricultural Marketing, Specialty Crops, Trade and tagged CalAgX, Export Training, Fresno CITD. Bookmark the permalink.

FOR IMMEDIATE RELEASE

MEDIA CONTACT: Monique Bienvenue, O: (559) 324-6401

CalAgX Sessions Set to Begin in April

FRESNO, California – March 13, 2015: The California Centers for International Trade Development (CITD) at State Center Community College District has announced the launch of their 10th annual California Agricultural Export (CalAgX) training seminar. A comprehensive export training program, CalAgX was designed to give California agribusiness leaders the tools to market their specialty crops in the food industry.

"CalAgX can provide businesses with the skills they need to become an international phenomenon," said CITD Director Alicia Rios. "Not only do the sessions provide real life case studies and examples, the sessions are taught by some of the most esteemed professionals in the export industry."

Held over a span of six weeks at three different locations, CalAgX is an all-inclusive export training program. Covering topics such as export logistics, terms of sale, legal and cultural aspects of the exporting industry, export payments and finance and credit insurance; CalAgX participants are prepared to bring their specialty crops to the global market.

This year, CalAgX is set to take place in Clovis, Salinas and Sacramento. Companies that participate should be at least one year old, and have less than two years' worth of export experience.

For more information about CalAgX and registration opportunities, click here: http://fresnocitd.org/services/calagx/.

About California Centers for International Trade (CITD):

The California Centers for International Trade's (CITD) mission is to promote the State's international trade and competitiveness, assist exporters and importers, and advance economic and job growth. The CITD specializes in food and agricultural export assistance and serves California through export training, one-on-one counseling, applied research and participating in CITD hosted buying missions. Since 2005, the CITD has maintained a Memorandum of Agreement with the California Department of Food and Agriculture (CDFA). Through the MOA, the CITD serves as the "ex officio" export division of CDFA and host all incoming buying mission to California. For more information, visit http://fresnocitd.org.

About State Center Community College District (SCCCD):

State Center Community College District (SCCCD) was formed in 1964 and currently serves approximately one million people and 18 unified and high school districts in more than 5,500 square miles of urban and rural territory, including most of Fresno and Madera Counties and portions of Kings and Tulare Counties. Total district enrollment averages over 40,000 students each semester. Its mission is to create lifelong learning and success for all students by providing accountable, accessible, innovative and quality educational and services that enable productive citizenship in a diverse, global society. For more information on SCCCD, go to www.scccd.edu.

###

CalAgX

YOUR WORLD. YOUR MARKET.

Open Enrollment for Class of 2015 Now through April 23th!

CalAgX is the ONLY comprehensive export training program available to California Specialty Crop executives – Open to all who Produce, Process, Market or Manufacture using California Specialty Crops

Approximately 1 in Every 3 Planted Acres is Destined for the Export Market

No Better Time to Export!

Come Out of CalAgX Knowing:

- **Enter New Markets & Locate Foreign Suppliers**
- **Logistics, Documentation & Incoterms**
- **How to Get Paid & Protect Your Investment**
- **Take Advantage of Export Promotion**

California Centers for International Trade Development — CITD

cdfa — CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Join more than 300 California Agricultural & Food product companies in completing the CalAgX training over the past ten years

Classes Start in April 2015 in Clovis, Salinas and Sacramento, CA

Call us at (559) 324-6401, email citd@scccd.edu, or visit our webpage www.fresnocitd.org/services/calagx

"I believe the CalAgX program with the combination of materials and speakers is a must for any company exporting or considering exporting as part of their marketing strategy."
Doug Stanley, Harris Fresh

"The CalAgX program gave me the tools to successfully open new international markets. I highly recommend this program to anyone interested in exporting"
Jeff Simonian, Simonian Fruit Company

"Great for people starting out in export. I recommend these classes to export new-comers"
Tammie McCoy, Blue Diamond Growers

The CalAgX program is hosted by the California Center for International Trade Development at State Center Community College District, and is funded by the 2012 Specialty Crop Block Grant program of the United States Department of Agriculture, and is presented by the California Centers for International Trade Development in cooperation with the California Department of Food and Agriculture

CalAgX

YOUR WORLD. YOUR MARKET.

money flows
WHERE INTERNATIONAL TRADE GROWS

CalAgX Training Can Be The Difference Between Success and Failure

The 9th Annual California Agricultural Export (CalAgX) training program will help you not only take your specialty crop to a global market, but will also save you time and money in the process! You'll connect with foreign buyers and global trade professionals during the course of the most comprehensive and insightful program in California!

TRAINING TOPICS *(Sacramento, Clovis, Lancaster):*

Please note that all sessions are from 9AM – 1PM

- **Session 01** (8/5, 8/6, 8/7) *"Sign of the Times"* - Food & Agricultural Exporting Essentials
- **Session 02** (8/12, 8/13, 8/14) *"Marketing to Your Market"* - Export Marketing and Promotion
- **Session 03** (8/26, 8/27, 8/28) *"Rules of the Trade"* - Food Export Regulations and Documentation
- **Session 04** (9/2, 9/3, 9/4) *"How It Works"* - Export Logistics & Terms of Sale
- **Session 05** (9/16, 9/17, 9/18) *"Making Dollars and Sense"* - Export Payments, Finance & Credit Insurance
- **Session 06** (9/23, 9/24, 9/25): *"Overcome Export Barriers"* - Legal & Cultural Aspects for Export

PAST PARTICIPANTS

Blue Diamond Growers, Earthbound Farm, Gold River Orchards, Grower Direct Nut Company, Mariani Packing Company, Meridian Nut Growers, National Raisin Company, Paramount Farms International, Summit Almonds, The Morning Star Packing Company, and more

REGISTRATION

CalAgX Registration Fee: **$249.00**

Early-bird Registration: **$199.00** (ends June 13, 2014)

Additional Company Representative: **$99.00** (**$120.00** after June 13, 2014)

CalAgX Registration Deadline: **July 25, 2014**

For more information, visit www.fresnocitd.org or call (888) 638-7888

PROGRAM QUALIFICATION CRITERIA

(all conditions must be met):

- Must be based in California
- In business at least 1 year (with a register Employer Identification Number)
- Have a qualified specialty crop product, as defined by USDA, that can be exported (includes processed food products that is made up of 50% or more of a CA specialty crop - excluding water, e.g. wine, jelly, canned peaches, etc.)
- Products grown and produced in California

DFA Of California | Specialty Crop Trade Council | Certified CCOF Organic | gavea Greater Antelope Valley Economic Alliance | California SBDC Los Angeles Regional Network | LA The Port of Los Angeles | cdfa California Department of Food & Agriculture

The CalAgX training program is funded by the 2012 Specialty Crop Block Grant program, and is presented by the California Centers for International Trade Development at State Center Community College District.

ONE WORLD - YOUR WORLD - YOUR MARKET

Presented by:
Center for International Trade Development - State Center Community College District

Going Global?

California Agricultural Export Training Program May Be for You!

What can the CalAgX do for you?

- Develop the "next steps" for your company to expand your **specialty crop** sales on a global scale
- Understand the financial and promotional export assistance that is available
- Establish contacts with experienced professionals in international finance, logistics and trade
- Respond to international sales inquiries and trade leads
- Learn the details of moving your product overseas and getting paid
- Identify and resolve company barriers to exporting

Program Overview:

The CalAgX benefits the producers, processors and marketers of California grown or processed **specialty crops**. The program consists of 6 separate training sessions held at two-week intervals with each session lasting 4 hours. Each of the 6 sessions has been designed to meet the learning needs of new-to-export or non-exporting food and agriculture companies. Sessions consist of:

- **Session 1:** Introduction to Food & Agriculture Exporting
- **Session 2:** International Marketing
- **Session 3:** Logistics & Documentation
- **Session 4:** Negotiation & Cultural Aspects
- **Session 5:** Financing Exports & Getting Paid
- **Session 6:** Foreign Regulations & Legal Aspects

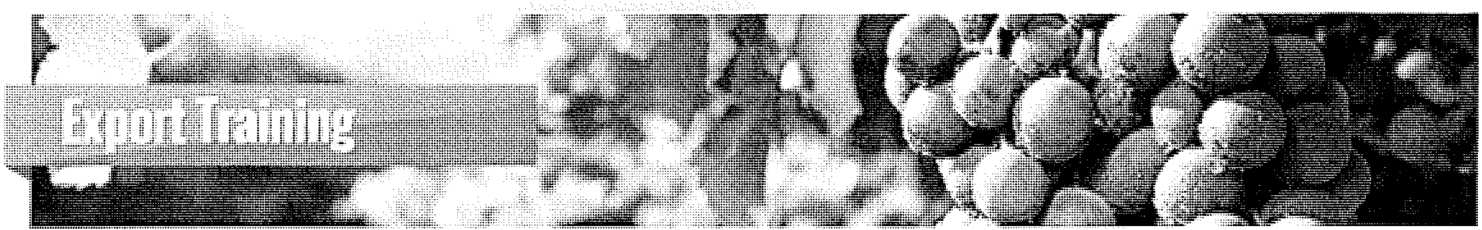
CalAgX 2013

Program Fee: $199.00
Add'l Representative: $75.00
Reg. Deadline: February 22, 2013

For More Information or to Apply Online, visit:
http://www.fresnocitd.org/services/calagx
(888) 638-7888

Class sessions will begin March 5-7, 2013 and end May 14-16, 2013.
Training sessions will be held in Clovis, Sacramento and Corona, California.

The CalAgX program is funded by the 2012 Specialty Crop Block Grant program of the United States Department of Agriculture, and is presented by the Fresno Center for International Trade Development in cooperation with the California Department of Food and Agriculture.



Export Training
CalAgX
Exporting Best Practices
Importing Into the U.S.
World Ag Expo
Training Videos
Trade Events
Resources
Technical Assistance
Success Stories

Event Description | Who Should Participate? | Agenda | Time and Location | Fees & Registration

CalAgX 2015 – Statewide Specialty Crop Export Certificated Training Series

Specialty crops... you grow them, but who's buying them? It's no secret that international sales is the next frontier in moving mass quantities of crops for your business. It's just simple math. The seven billion plus people living on Earth is more than the 300 or so million here in the United States. Figuring out a way to get your crop to other countries could be the way to grow your farm and your business in ways you never even imagined. The six-session California Agricultural Export (CalAgX) training program will help you not only figure these things out, but will also save you time and money in the process! You'll connect with foreign buyers and global trade professionals during the course of this program, which is the most comprehensive and insightful program available in California!

The CalAgX benefits the producers, processors and marketers of California grown or processed specialty crops. The program consists of 6 separate training sessions held at two-week intervals with each session lasting 4 hours. Each of the 6 sessions has been designed to meet the learning needs of new-to-export or non-exporting food and agriculture companies.

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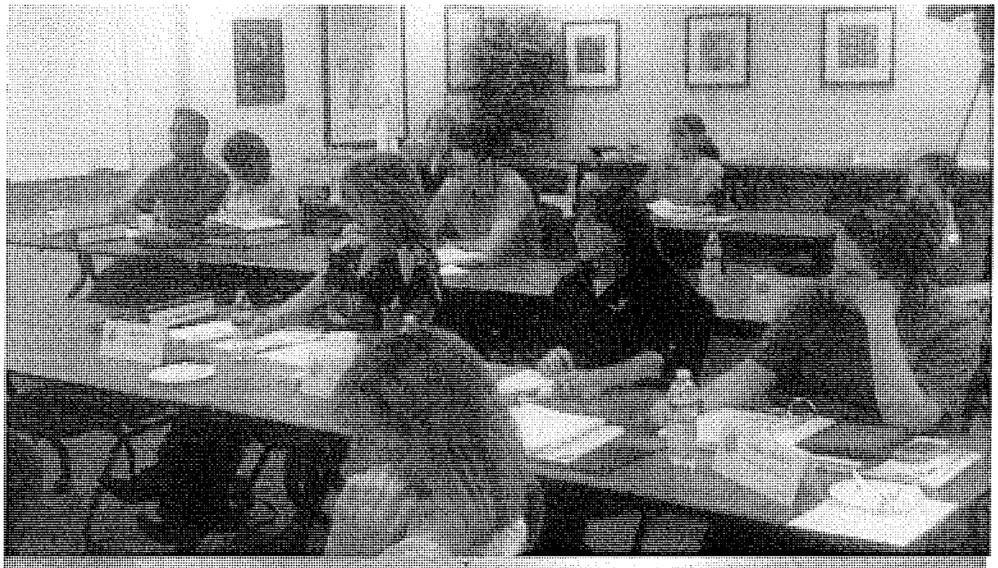

California

June 12 & 13, 2014

Presented by:

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

www.cdfa.ca.gov

California Centers for International Trade Development

www.fresnocitd.org

USDA Foreign Agricultural Service

USDA Agricultural Trade Office · Shanghai

Nut Buyer Inbound Mission

June 12 & 13 · 2014 · Modesto · Fresno Area

China is the largest export markets for U.S. tree nuts . With 1.3 billion inhabitants, China represents 20.7% of the world's population. Shanghai is ranked as one of the largest urban areas in China with the best infrastructure and greatest number of experienced distributors. With increasing household incomes and food safety concerns, more consumers are trading up to buy imported foods.

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Suitable products include, but are not limited to:

- **Nuts – Walnuts, Almonds, Pecans, Pistachios**

Products must be at least 50% U.S. agricultural origin by weight, excluding added water and packaging.

Company profiles will be available for distribution, detailing specific categorical requests of participating buyers.

For more information, please contact:

· Amber Balakian, California Centers for International Trade Development, at (559) 324-6401 or email: amber.balakian@scccd.edu

· If you are interested in registering for this activity, please complete and return the attached reservation form via by: Friday · June 6 · 2014

□ June 12 · 2014 · **Tabletops** · Modesto, CA
□ June 13 · 2014 · **Site Visits** · Fresno, CA

***Site Visits designated for buyers only. Vendor sign-up on first come first serve basis.**

Program location will be provided upon registration.

Register Online Here

CALIFORNIA GROWN TRADE MISSION TO CHINA FOCUSED ON SPECIALTY CROPS

May 28 – June 6, 2015
Hong Kong • Shanghai • Hangzhou • Beijing

TRAVEL ITINERARY

(Updated on May 27, 2015)

In-market Contact:
Roger Zhang-86-13601873080
SMH International
Mobile: 86-13601873080
smh-shanghai@163.com
Tel: +86 21 6888 9836

Alicia Rios
California Center for International Trade Development
Alicia.rios@scccd.edu
(559) 360-4560

Purpose: The California Trade Mission to China will focus on the promotion and consumer awareness of California Specialty Crops.

DELEGATION MEMBERS

1. Nicolas Matteis (Lead), California Grown
   (916) 517-9169 • nmatteis@agamsi.com
2. Alicia Rios (Co-Lead), California Center for International Trade Development
   (559) 360-4560 • alicia.rios@scccd.edu
3. Robin Boyle, California Certified Organic Farmers
   (408) 497-7753 • rboyle@ccof.org
4. James Johansson, California Farm Bureau Federation
   (530) 990-5783 • jjohansson@cfbf.com
5. Peter De Young, California Fig Advisory Board
   (559) 994-9292 • deyoung.jp@gmail.com
6. James Crisp, Crisp Walnuts
   (559) 904-5221 • jim@crispwarehouse.com
7. Michael Miya, Miya Farms
   (559) 309-3300 • miyafarms@gmail.com

Calling U.S. number from Hong Kong: 001 + 1 + City Area Code + Phone Number
Calling U.S. number from China: 00 + 1 + City Area Code + Phone Number

OVERSEAS CONTACTS

1. Roger Zhang, SMH International
   +86 136 0187 3080 • smh-shanghai@163.com

****
****

Wednesday, May 27, 2015 – Depart California

Thursday, May 28, 2015

Arrive in Hong Kong International Airport

- *Option 1: take the cab to hotel directly and the cost is HK$360(US$46)*
- *Option 2: take the express train to HK station (HK$100 =US$13) first , then take the cab to hotel (HK$30=US$4)*

The Conrad Hotel Hong Kong (A member of Hilton Hotels Worldwide)
Pacific Place, 88 Queensway, Hong Kong
Tel. +852.2521.3938
-- SMH has paid the accommodation for all participants and hotel will need your credit card which is for incident cost only.

Hotel confirmation:

Alicia Rios	318 369 9487
James Crisp	318 353 0379
James Johansson	318 644 8175
Michael Miya	318 213 0188
Nicolas Matteis	318 441 6233
Robin Boyle	318 522 3664

Friday, May 29, 2015 – Hong Kong

8:00 AM Meet in the hotel lobby and walk to the ATO office
-please bring your passport

8:30 AM-9:30AM ATO Market Briefing
Ms. Alkie Tsang, American Marketing Assistant, Agricultural Trade Office, American Consulate General, Hong Kong

Dress Code: Business/Business Casual (closed shoes)

10:15AM-12:00PM Retail Tour arranged by SMH
-" Great " Supermarket
-The chef from supermarket will show us the kitchen facility & store

Lunch (no host)

1:30 – 3:00 PM **California Wines Seminar led by Karen MacNeil**
Location: Harcourt Room, Grand Ballroom Lower Level, The Conrad Hotel Hong Kong

Display table will be arranged, products including almonds, grapes, raisins, walnuts, pistachios, tree fruits, strawberries, figs, olive oil

3:00-5:00 PM **Wine Trade Tasting** (In conjunction with the Wine Institute)
Location: Granvile & Nathan Room, Grand Ballroom Lower Level, The Conrad Hotel Hong Kong

SMH to invite buyers
-HK key traders and retailers meeting, 15 key buyers and retails will be invited
-CA Grown products will be displayed (varies by market availability)

7:00 – 9:30 PM **Wine Consumer Tasting** (In conjunction with the Wine Institute)
Location: Granvile & Nathan Room, Grand Ballroom Lower Level, The Conrad Hotel Hong Kong

Dinner (on your own)

Saturday, May 30, 2015

9:15 AM Meet in the hotel lobby
--Port Tour- Chris from ATO HK will be tour guide
--Wet Market Tour (Kowloon)
--Retail Tour –Welcome, Jusco

Dress Code: Casual (comfortable shoes no shorts)

After 12:00 PM Free Time

Group Dinner

Sunday, May 31, 2015 – Travel to Shanghai

8:30 AM Meet in the hotel lobby for airport
-transportation will be arranged by SMH

Flight: KA804 (10:55-13:30PM) HK to Shanghai
-SMH has booked tickets for all participants

Hotel: Jing An Shangri-la
1218 Middle Yan'an Road, Jing An Kerry Centre, West Nanjing Road, Shanghai, China
Tel. +86 (21) 2203 8888
-- SMH has paid the accommodation for all participants and hotel will need your credit card which is for incident cost only.

Monday, June 1, 2015 – Shanghai, China

8:00 am Meet in the hotel lobby and walk to ATO Shanghai Office
-please bring your passport

8:30 am-9:30am ATO Market Briefing
Shanghai Center, Suite 331, 1376 Nanjing West Road, Shanghai, China 200040

Dress Code: Business/Business Casual (closed shoes)

9:45-10:15 am Meetings with YHD.com at ATO Shanghai office

10:15-10:45 am Meeting with kjt.com or Fruitday.com at ATO Shanghai office

11:30 am-12:30 pm Meetings with CA China Office
Address: TBD

Lunch (no host)

1:30 – 3:00 PM **California Wines Seminar led by Karen MacNeil**
Location: TBD
-Display table will be arranged for CA Grown products (varies by market availability)

3:00-5:30 PM **Wine Trade Tasting** (In conjunction with the Wine Institute)

SMH to invite buyers
-Shanghai key traders and retailers meeting, 20 key buyers and retails will be invited
-CA Grown products will be displayed (varies by market availability)

7:00 – 9:00 PM **Consumer Wine Tasting** (In conjunction with the Wine Institute)
Location: TBD

Dress Code: Business Casual – Sports Jacket

Tuesday, June 2, 2015 – Travel Day to Hangzhou

9:30 am Meet in the hotel lobby for Hangzhou
-the Van will be arranged by SMH

12:30PM Arrive in Hangzhou

J.W. Marriott Hotel Hangzhou
28 Hushu South Road, Gongshu District, Hangzhou, Zhejiang
Tel. +86 (21) 8578 8888
-- SMH has paid the accommodation for all participants and hotel will need your credit card which is for incident cost only.

Wednesday, June 3, 2015 – Hangzhou, China

10:30 am	Meet at hotel lobby and go over the agenda for Media Tasting Event
11:00am-12:30pm	CA Grown Media Tasting Event in Hangzhou Venue: Function room of JW Marriott Hotel Hangzhou --20 media will be invited

Dress Code: Business/Business Casual

1:00 – 2:30 PM	**California Wines Seminar** (tentative) Location: TBD - Display table will be arranged, products including almonds, grapes, raisins, walnuts, pistachios, tree fruits, strawberries, figs, olive oil
3:00-5:30 PM	**Wine Trade Tasting** (In conjunction with the Wine Institute) Location: TBD
3:15PM	Meet in the hotel lobby for meeting with Tmall Transportation will be arranged by SMH
4:00-5:00 PM	Meeting with Tmall
7:00 – 9:00 PM	**Consumer Wine Tasting** (In conjunction with the Wine Institute) Location: TBD

Dress Code: Business/Business Casual

Thursday, June 4, 2015 – Travel Day to Beijing, China

5:30 am	Meet in the hotel lobby for Airport Flight: MU5131 (7:30-9:40AM) Hangzhou to Beijing -SMH will book the ticket for all participants ***The St. Regis Hotel Beijing*** 21 Jianguomenwai Dajie, Beijing, 100020, China *-- SMH has paid the accommodation for all participants and hotel will need your credit card which is for incident cost only.*

Dress: Casual for airport

11:00 am	Market briefing at U.S. Embassy American Embassy, No 55 An Jia Lou Lu Road, Chaoyang District, Beijing, China 100600 ● According to ATO Beijing's suggestion, we will go to U.S. Embassy directly from Beijing Airport. After the briefing, we can go to hotel for check in ● If it is OK for everyone, we can arrange the retail tour and city

orientation in the afternoon

<u>Friday, June 5, 2015 – Beijing, China</u>

6:30 am	Meet in the hotel lobby
8:00 -9:30 am	Bakery Manufactory Visit -Rondam Dairy
11:00 am -12:00pm	Meeting with Holiland Bakery Chain

Dress Code: Business Casual (closed shoes)

Lunch (no host)

1:00 – 2:30 PM **California Wines Seminar (tentative)**
Location: TBD

3:00-5:30 PM **Wine Trade Tasting** (In conjunction with the Wine Institute)
Location: TBD

SMH to invite buyers
-Beijing key traders and retailers meeting, 20 key buyers and retails will be invited
-CA Grown products will be displayed (varies by market availability)

7:00 – 9:30 PM **Wine Consumer Tasting** (In conjunction with the Wine Institute)
Location: TBD

Dress Code: Business/Business Casual

Notes: All tasting are open to all participating wineries who have a representative present and to local distributors of Members' wines.

<u>Saturday, June 6, 2015 – Beijing, China</u>

Check out depart for the airport

Please note agenda is subject to change appointment are being finalized.

This trade and promotional mission is funded through the Specialty Crop Block Grant program of the United States Department of Agriculture, and is presented in cooperation with the California Department of Food and Agriculture and the California Centers for International Trade Development.

California

June 12 & 13, 2014

Presented by:

cdfa

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

www.cdfa.ca.gov

www.fresnocitd.org

USDA

Foreign Agricultural Service

This trade activities is funded in part by the 2012 USDA Specialty Crop Block Grant Program.

USDA Agricultural Trade Office · Shanghai

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June 12 & 13 · 2014 · Modesto · Fresno Area

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Register Online Here

Canned Fruit Focus Groups

Sacramento – December 11, 2012

Executive Summary

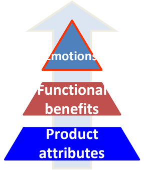
December 19, 2012

Table Of Contents

Project Process

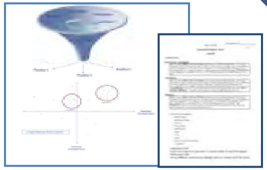
Qualitative Research to uncover opportunities

Quantitative Research Phase I



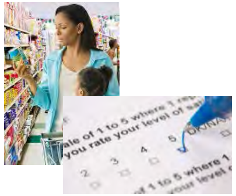
Workshop: Positioning statement Developed

Concept Development



Quantitative Research Phase II

Pilot Test Developed



Insights from Pilot

Pilot Findings/Insights/ Next Steps

Focus Group Overview

COGNISE Consulting

Objectives:

- First step in understanding:
  - The opportunity to capitalize on recent nutrition studies showing the health advantages of canned fruit, specifically Peaches and Apricots.
  - The issues that need to be overcome as it relates to consumer understanding of canned fruit
  - The opportunity to develop a communication message that will resonate with consumers and be effectively implemented in-store
- Will be used to inform the next step in the project
  - Quantitative questionnaire to identify and optimize most compelling consumer message

Focus Group Insight Areas

Questions to be answered to optimize canned fruit positioning statement

- What are the challenges for consumers who try to serve nutritious food to their families, especially their kids? How do they meet these challenges?
- How does fruit fit in? (fresh and canned)
- What are the needs that consumers seek to fulfill when they purchase canned fruit as opposed to fresh (or visa versa)?
- What are the perceived benefits and drawbacks of canned vs. fresh fruit?
- What is the basis for these perceptions? How can they be changed?
- How do consumers view the nutritional profile of canned fruit vs. fresh?
- How well received are factual nutritional claims for canned fruit? How can they be made more motivating?

Study Overview – Method & Sample

Method

- Three focus group discussions – 90 minutes each.
- Completed in Sacramento, CA on 12/11
- Discussions among three different groups of women:

Questions	Group 1: Canned Fruit Users/ Loyalists (8 respondents)	Group 2: Light canned users (6 respondents)	Group 3: Young Light Canned users (9 respondents)
Age:	30-49	30-49	21-29
Kids:	6-14	6-14	3-9
Canned Fruit Usage	Heavy Canned Users 2-3 X per week+	Light Canned Users 1-3 x per month	Light Canned Users 1-3 x per month
Future openness to canned Fruit	Yes	Yes	Yes
Health minded	Not necessarily	Not necessarily	Yes

Overall observations

Respondents in all the groups:

- Were more likely to shop at farmer's markets.
- Shopped at a cross section of outlets, not primarily in grocery stores.
- Lived in the Central Valley - familiar with the fruit growing economy of the region.
- Had a low incidence of canned apricot consumption
  - Quantitative data indicates that apricot consumption is highest in the US southeast
- Had similar responses as it related to canned fruit.
  - The availability of fresh fruit in California may have skewed their canned fruit attitudes and behaviors

Additional knowledge from other regions of the US could add further depth to these findings.

Findings: Focus Group Themes

The following consumer themes regarding canned fruit emerged.

1. Effect of canning on nutrients/same nutrients as fresh
2. Misconceptions of the canning process/picked fresh
3. Heritage of canning
4. Canned fruit's specific healthy ingredient claims
5. Advantages from family farms/farming
6. Convenient snacking
7. Learnings from breakfast cereals

1. Effect of Canning on Nutrients

- Consumers find it difficult to believe that canned has more nutrients than fresh.
- More likely to believe that canned nutrients are equal to fresh.
- View fruit canning as another processed food product and processing is viewed negatively. However, there was no mention of BPA.
- A strong endorsement from a trusted resource, such a Dr. Oz is compelling.

Conclusion:

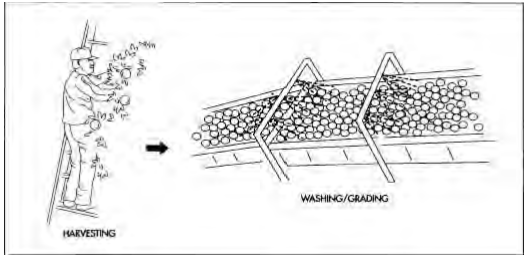
- There may be an opportunity for claims around the canning process that “locks in” freshness and “activates” nutrients.

2. Misconceptions of Canning/Picked Fresh

- Fruit canning process is not widely understood.
- Fresh picked and packed successfully used in previous campaigns.
- “Picked at the peak of ripeness” is believable.
- Helps to imply that canned fruit is competitive with fresh.

Conclusions

- Canning process may be a difficult story to tell due to complexity.
- Need to understand how to develop a concise story.



3. Heritage of Canning

- There are significant misperceptions of the canning process
  - Most are familiar with old fashioned canning, do not believe this is similar.
  - Believe that canning is heavily processed with additives and other ingredients, including sugars.
  - Do not understand how a product could be good for you and be able to last that long stored in a can.
  - Once the process was explained, consumers were interested in hearing more

Conclusion

- Might be possible to leverage an emotional connection around "grandmother/old fashioned" canning process.

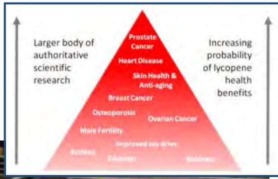
Nutrition Claims Tested

Claims Tested	# Times ranked in the top 3 (Total of 23 respondents*)
Same Nutrients As Fresh	18
Picked At The Peak of Ripeness	15
Same Sugar as Juice Pack	7
Higher in Vitamin A Than Fresh	7
Nutrients Increase Thanks to Canning Process	5
Higher in Carotenes than Fresh	3
10 x Higher in Folate Than Fresh	3

* Note: Not all respondents ranked top 3 choices.

4. Canned Fruit Healthy Ingredient Claims

- Canned fruit is viewed as being processed and consumers are skeptical about the healthiness of all processed food.
- Specific claims were met with skepticism – wanted more data
- Some were aware of the positive health benefits of tomatoes but no-one recalled Lycopene.
  - Consumers have been shown in the past to be responsive to positive health claims about processing.



Conclusion:

- Consumers may be open to the possibility of nutrition claims for canned fruit but, need to overcome negatives about processing.

5. Advantage from Family Farms

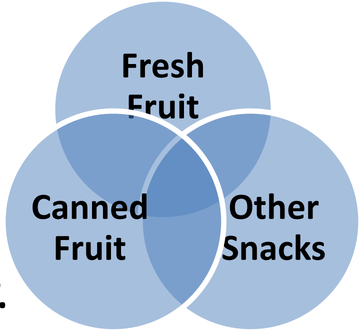
- Consumers are skeptical of the family farming concept. They believe that these are big corporations who grow and pack most of the fruit sold in the US.
- Not aware of high number of family owned farming businesses, once aware they are more interested in the quality of the product in the can.

Conclusion:

- May be an opportunity around the human element of family farms together with the wholesomeness of canning.
- Could be difficult to communicate how family farming is distinctive and different.

6. Convenient Snack

- The competitive frame for canned fruit extends beyond fresh fruit to other snacking items.
- Viewed as a "good for you" alternative in a snack for kids in school lunches, on the go meals or added as part of a meal.
- Some issues with messy liquids, which are not convenient.
- May not directly compete with fresh fruit.
- Usage of canned fruit also in meals, marinades, side dishes



Conclusion:

- The role of canned fruit appears to be primarily snacking, need to understand use as part of meal or a meal enhancer.

7. Opportunity to learn from Breakfast Cereals

- Breakfast cereals use the claim, “As part of a healthy lifestyle” to link cereal to overall health and nutrition.
- Can we link fruit to healthy living using the same type of strategy?

Conclusion:

- Need to uncover more information about the opportunity to leverage canned fruit as part of a total healthy lifestyle.

Possible Messaging Direction

- Fresh picked and fresh packed
- Fruit as a part of your healthy lifestyle
- Canning that locks in the freshness and nutrients
- The canning process contains more of (Nutrient), which is proven to reduce (Disease)
- Fruit the way your body wants it
- Healthy convenient snack
- Recapturing youth
- Found in nature found in me
- Finally, it is my choice
- Dispelling the myth (Of Canning)
- Dr. Oz approved – canning does improve the nutritional value of fruit.

Immediate Next Steps

- Develop questionnaire for Phase I quantitative research
- Field Phase I web based research

In-store retail test pilot

Before and after photo of the shipper

Here are the actual sales numbers from the Jan 17-18 program:

10

UPC Breakdown

Peaches & Apricots (Save Mart)

Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	28	$36	50	$75	80%
71754410703	Peach Snack Bowls	16	$41	51	$128	214%
71754412668	Apricot Snack Bowls	1	$3	23	$58	1740%
71754410707	Sliced Peaches in Juice	31	$39	41	$62	33%
Total Event		76	$118	165	$322	117%

Non-Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	1,025	$1,387	942	$1,435	-8%
71754410703	Peach Snack Bowls	568	$1,427	644	$1,603	13%
71754412668	Apricot Snack Bowls	101	$255	146	$361	45%
71754410707	Sliced Peaches in Juice	1,171	$1,577	1,092	$1,650	-7%
Total Non-Event		2,864	$4,646	2,824	$5,050	-1%

Interactions
in good taste

9

UPC Breakdown

Peaches & Apricots (Lucky)

Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	15	$26	23	$41	59%
71754410703	Peach Snack Bowls	2	$5	14	$39	700%
71754412668	Apricot Snack Bowls	4	$11	8	$22	113%
71754410707	Sliced Peaches in Juice	10	$17	19	$34	100%
Total Event		30	$59	64	$136	117%

Non-Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	399	$714	400	$716	0%
71754410703	Peach Snack Bowls	127	$370	212	$499	67%
71754412668	Apricot Snack Bowls	39	$114	63	$141	62%
71754410707	Sliced Peaches in Juice	348	$622	334	$598	-4%
Total Non-Event		913	$1,821	1,009	$1,954	11%

Here are the sales numbers from the Feb 7-8th program

9

UPC Breakdown

Peaches & Apricots (Save Mart)

Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	24	$35	42	$63	79%
71754410703	Peach Snack Bowls	25	$38	39	$59	54%
71754412668	Apricot Snack Bowls	18	$46	32	$80	75%
71754410707	Sliced Peaches in Juice	3	$8	26	$65	767%
Total Event		70	$126	139	$267	99%

Non-Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	1,014	$1,536	1,022	$1,549	1%
71754410703	Peach Snack Bowls	951	$1,442	808	$1,236	-15%
71754412668	Apricot Snack Bowls	669	$1,676	665	$1,687	-1%
71754410707	Sliced Peaches in Juice	130	$327	113	$286	-13%
Total Non-Event		2,763	$4,981	2,608	$4,759	-6%

10

UPC Breakdown

Peaches & Apricots (Lucky)

Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	12	$21	18	$36	57%
71754410703	Peach Snack Bowls	13	$24	21	$42	65%
71754412668	Apricot Snack Bowls	5	$13	16	$48	205%
71754410707	Sliced Peaches in Juice	7	$19	9	$27	24%
Total Event		37	$76	64	$152	74%

Non-Event Stores						
		4 Wk Prior Average		Event		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410689	Apricot Halves	308	$563	185	$368	-40%
71754410703	Peach Snack Bowls	363	$661	302	$601	-17%
71754412668	Apricot Snack Bowls	193	$513	216	$644	12%
71754410707	Sliced Peaches in Juice	58	$153	45	$135	-22%
Total Non-Event		921	$1,891	748	$1,748	-19%

Here are the sales numbers from Feb. 20th & 27th (1 event only; 1 store only):

4

UPC Breakdown

Peaches & Apricots

1 Event Stores						
		4 Wk Prior Average		Event Week		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410707	Peach Sliced Juice	7	$10	3	$5	-54%
71754410689	Apricot Halves	8	$12	8	$12	-3%
71754410703	Peach Fruit Snack Bowls	8	$19	13	$28	63%
71754412668	Snack Bowls Apricots	1	$3	7	$15	460%
Total Event		24	$44	31	$59	29%

164 Non-Event Stores						
		4 Wk Prior Average		Event Week		Lift %
UPC	Flavor	Units	Sales $	Units	Sales $	Units
71754410707	Peach Sliced Juice	1,260	$2,005	1,148	$1,832	-9%
71754410689	Apricot Halves	2,141	$3,117	1,837	$2,720	-14%
71754410703	Peach Fruit Snack Bowls	1,254	$3,164	1,307	$3,071	4%
71754412668	Snack Bowls Apricots	195	$487	179	$426	-8%
Total Non-Event		4,849	$8,774	4,471	$8,049	-8%

The 411 on Canned Fruit Nutrition

The science is in: researchers at Oregon State University and the Linus Pauling Institute have discovered that canned peaches pack a nutritional punch! Picked and packed at the peak of freshness, canned peaches offer year-round nutrition.

Reality Check

Only 33% of Americans are meeting the recommendation for fruit consumption *(Source: CDC)*

Only 42% of Americans realize that the nutrients in canned fruit count towards meeting the U.S. Department of Agriculture guidelines *(Source: Canned Food Alliance)*

52% of all FRESH produce grown every year is wasted *(Source: Rodale News)*

Nutrition Check: Canned Peaches vs. Fresh Peaches

Canned Peaches are...

4x's higher in Vitamin C

10x's higher in Folate

1.5x's higher in Antioxidants

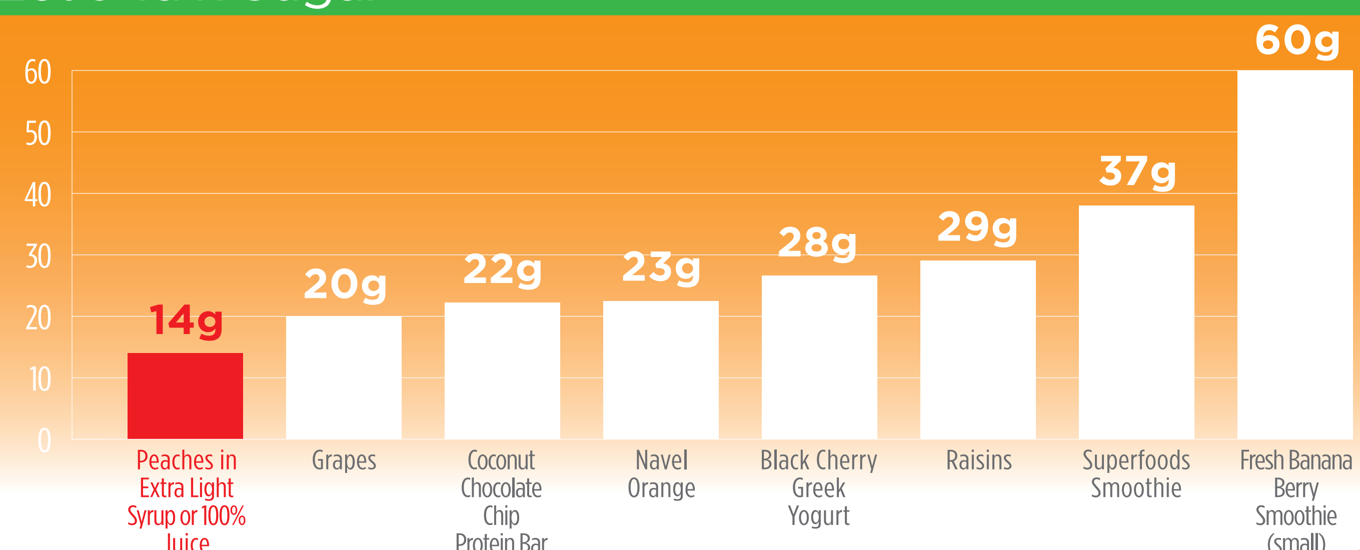
Comparable in Vitamin E

(Source: Oregon State University)

Bonus!

- **Grown locally in the USA**
- **Picked Fresh, Packed Fresh**
- **Recipe Ready**
- **Reduced Waste + Recyclable Container**

Let's Talk Sugar



California Cling Peaches @CalClingPeach www.calclingpeach.com www.apricotproducers.com

California Canned Peaches & Apricots:
The 100% Healthy Snack

--A recent study from Oregon State University (OSU) shows that California Canned Peaches are just as nutritious as fresh
--California Canned Peaches and Apricots are grown locally on family farms
--Picked at the peak of ripeness; NO preservatives or artificial ingredients

Loaded with Nutrition and Taste Delicious Anytime, Anywhere!
--Your fridge isn't just for fruit cups! Keep a can cool for a ready-to-eat healthy snack. And yes, you can re-cover the can and put back in the fridge!

--CA Peach and Apricot cups are great for sport team snacks & grown-up lunches too!

--Add CA peaches and apricots to salads, smoothies & cereal; top yogurt, pancakes & pizza; dice and add to tacos, burritos or fold into sandwich wraps with extra greens

Would YOU Like to Win California Canned Peaches & Apricots for a Year?!
Visit www.calclingpeach.com for details and Thank You for Your Support!

YUMMY RECIPE ON BACK >>>>>>>>>!!!!!

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YUMMY RECIPE ON BACK >>>>>>>>>!!!!!

CALIFORNIA PEACH SALSA:

Ingredients :
1 can (14 oz) California Cling Peach slices
1 can 4 tsp White wine vinegar
4 tsp Lime juice
2 tsp Lime peel, finely grated
3 tbsp Fresh mint, chopped
1/4 cup Fresh coriander, chopped
1/4 tsp Black pepper
1/4 tsp Salt
1 tbsp Olive oil
3/4 cup Diced pineapple, drained
1/2 cup Fresh orange segments, chopped
1/2 cup Cucumber, finely chopped 125 mL 1
/3 cup Red onion, finely chopped
3 tbsp Seeded jalapeño peppers, finely chopped
Method:
1. Drain peaches and dice into small pieces. Reserve. 2. In a large bowl, combine vinegar, lime juice, lime peel, mint, coriander, pepper and salt.
3. Whisking, drizzle in oil. Add peaches, pineapple, oranges, cucumber, red onion, and jalapeño. Gently stir until well mixed. 4. Cover and serve chilled.
Tip: Serve with tortilla chips or use salsa as a condiment for grilled fish, chicken or pork. It's also great on chicken or fish burgers!
Makes 8 Servings

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CONSUMER SURVEY

Commissioned by El Dorado Wineries Association

FULL GLASS RESEARCH

June 2015

Table of Contents

Introduction and Methodology

Goals

The El Dorado Winery Association commissioned Full Glass Research to carry out market research that would to measure consumer awareness and opinions of the region and its wines, as well as interest in, and experience of, wine tourism in the region. In addition, a comparison of consumer opinions vs. an earlier survey executed in 2013 was requested.

The market research was designed to provide the following information:

- Identify the wine drinking habits and preferences of the target consumers.
- Profile their wine-related tourist activity in terms of occasion, preferences and regional features.
- Measure their awareness and familiarity with of El Dorado wines, as well as some competitor regions.
- Measure their opinion on quality, value, and traits of El Dorado wines.
- Measure visitation to, and activities within, the El Dorado region.
- Measure awareness of, or exposure to, various promotions or publicity related to El Dorado wines.
- Compare results for key benchmark questions vs. the original 2013 study.
- Uncover any correlations between awareness, visitation or perception of El Dorado wines and promotions, publicity or demographic variables.

Methods

Full Glass Research (FGR) and the El Dorado Wineries Association (EDWA) designed a consumer survey, to be executed via the internet. This survey repeated some of the basic measures of awareness and experience with El Dorado wines from the 2013 survey, and added new measures of quality, value, varietal preferences, exposure to publicity and wine tourism activity. A copy of the survey may be found in the appendix to this report.

The survey was fielded to a sample of consumers matching the characteristics of the original 2013 sample, in order to provide meaningful comparison of results. The consumer sample was provided by Research Now, the same company that provided the online consumer sample for the 2013 study. The 2013 sample specifications were followed:

- 1000 respondents;
- over 21 years of age;
- have consumed table wine (i.e. not just sparkling, fruit or fortified wine) within past 4 weeks;

- household income of $50,000 or more;
- have attended college;
- resident of California or Nevada;
- approximate gender balance (each gender between 40-60%).

The consumer sample was recruited by Research Now and routed to the survey built and managed by Full Glass Research. A total of 1,148 qualified respondents completed the survey between May 8th and May 21st 2015.

The sample in the 2013 survey was split between 54% Californian and 46% Nevadan respondents. This is not at all representative of the relative sizes of the wine-drinking populations in the respective states, nor their total wine consumption (which would be 90-92% Californian). The EDWA board felt that a California/Nevada split of 75% Californian to 25% Nevadan was more representative of the target market for El Dorado, so soft quotas in that ratio were applied to the sample recruiting.

The final sample came in very close to the original 2013 in terms of demographics, with one exception – the proportion of respondents attending graduate school or with graduate degrees was higher than both the 2013 sample and the norms for core wine drinkers established by the Wine Market Council's annual tracking study (28% vs. 21-22%). Therefore all the data analyzed for this report was weighted to match the proportion of graduate students in the target population (22%).

Calculated at a 95% confidence interval, the margins of error for the total respondents to the survey range from +/-1.3% to +/-2.9%. Where significant differences are described between measures and groups within the survey, they have been calculated at a 90% or 95% confidence interval.

In addition to the survey totals, the data was analyzed for significant variations by the following variables:

- age;
- gender;
- region of residence;
- high end consumers ("HE"=those who consumed $30+ wines monthly or more often);
- level of familiarity with, and previous visitation to, El Dorado;
- frequent Red Zinfandel drinkers.

Key Issues from the Board

In planning discussions for this project with the EDWA board and administration, a number of issues emerged as the leading ones on which to focus our analysis. This section will examine the survey results as they apply to the board's key issues.

Awareness and image of El Dorado wines:

- Awareness and familiarity are key issues for El Dorado. The majority of wine consumers surveyed have no distinct image or attributes for El Dorado or its wines. Nearly half said they were unfamiliar with wines from El Dorado; 64% felt too unfamiliar to rate the wines. Fewer than 15% associated the wines with particular attributes, although up to 39% associated some attribute with the wine region.
- Quality and value ratings for El Dorado wines were slightly below Amador, well below Sonoma and Paso Robles, but ahead of Lodi.
- The most common unaided associations with El Dorado were "gold country", "mountains/hills", Hispanic-related words/themes and Zinfandel. The most frequently chosen aided attributes were "friendly, family-run wineries" and "gold country."
- Region of residence had a major impact on awareness and perceptions of El Dorado.
    - Only 1 in 10 respondents living in the Sacramento, Foothills or Reno regions were unaware of El Dorado wines, whereas 43-61% of residents in the SF Bay area, LA-San Diego and Las Vegas regions were unaware of the wines.
    - About ¼ of those in the Sacramento, Foothills, Reno and SF Bay regions had visited the area vs. 4-18% of respondents in other regions.
    - Residents of nearby Sacramento-Foothills and Reno regions had higher quality and value ratings for El Dorado, but not necessarily superior ranking of El Dorado vs. other regions. They had higher associations of El Dorado with a variety of attributes and a more precise notion of El Dorado's geography and relationship to the Sierra Foothills region.
- High End wine consumers are slightly more positive on El Dorado wines, but are no more familiar with the region and actually have lower visitation rates. Regular consumers of Red Zinfandel are also more familiar, have higher visitation rates, but not higher quality and value ratings for El Dorado. Among regions measured in this survey, only Lodi appears to have picked up a significant boost in quality ratings from regular Red Zinfandel drinkers.

Wine Tourism

- Among the wine consumers surveyed, 2/3 are regular wine country tourists and nearly ¼ visit wine regions at least several times a year.
- Visitation levels to El Dorado are roughly the same as Amador, higher than Calaveras, slightly behind Lodi and way behind Paso Robles and Sonoma. El Dorado visitors are somewhat more likely to be 55 years or older and drink more $10-30 wine than the average wine consumer surveyed.
- Two of the leading reasons for visiting El Dorado wine country are "passing through" or other business/personal activities; just over half of visitors ascribed one of these. These rates are even higher for SF Bay area and LA-San Diego region residents. The other major reasons are having tried/enjoyed the wines and interest in visiting new and intriguing wine regions.
- Intent to return to El Dorado is 24%, about average for the wine regions tested.
- Only 1/3 of visitors stayed overnight in a hotel or B&B. About ¼ engaged in outdoor activities such as hiking and biking; 41% of wine consumers are interested in such activities in a wine region. The leading activities of interest in wine country are visiting/discovering small family wineries and tasting new or unknown wines. About 1/3 are very interested in events, festivals, music or special sit-down tastings.
- The impact of visitation on perceptions of El Dorado is dramatic, resulting in:
  - significant increases in quality and value ratings;
  - very large increases in association with many attributes, including "up-and-coming wine region", "big red wines", "consistent quality", "natural beauty" and "historic sites".
  - an increase in the identification of El Dorado with Sierra Foothills wines.

Effects of Communication or Promotion:

- Of those who had visited El Dorado, 11-14% had attended various events; 19-23% had been exposed to El Dorado via some kind of media coverage. However, 1/3 of visitors were unaware of the Passport event and 41-54% were unaware of the other events listed. 52% of those attending events were from the Reno or Sacramento-Foothills regions.
- Event attendance significantly boosts quality and value ratings for wines of both El Dorado and Amador. Media exposure also increases ratings, although not as much.

- Those attending events or exposed to El Dorado-related media are more opinionated and more likely to associate El Dorado with positive attributes. They are less likely to consider El Dorado "out of the way, hard to get around" and much more likely to perceive the Sierra Foothills connection and similarities with other Sierra wines.

Comparison with 2013 Data

- Comparison with the 2013 data was hindered by the lack of raw data results and/or comprehensive and complete tables for 2013. In addition, some measures and questions were altered to make them more useful or applicable to the current goals of the EDWA.
- Among those data that were comparable, the following significant observations were made:
    - There was a decrease from 2013-2015 in the percent of consumers "unfamiliar" with El Dorado.
    - There was an increase in the percent of wine tourists who had visited El Dorado.
    - There was a decrease in the proportion agreeing that El Dorado was "hard to get around, out of the way."
    - There was a decrease in the percent describing El Dorado as "up and coming", but an increase in those associating it with "friendly, family run wineries."
    - The most entered types of open-end attributes in 2015 were "gold country", "mountains/hills", Hispanic associations, Zinfandel and various positive descriptors. In 2013, the most frequently entered types were "gold country", "red wines", Hispanic associations and general positive descriptors.

Positioning El Dorado:

- El Dorado's appeal and familiarity is highly skewed towards regions that are close-by. Awareness, trial and perception are all much higher in the Sacramento-Foothill and Reno regions, and trail off elsewhere. More promotion and visibility are needed in markets outside the 2 hour driving radius.
- A large proportion of visitors are making detours or side trips to wineries while in the El Dorado region for other reasons. This factor should be considered, representing both an opportunity (how can more visitors be "re-routed" to wineries) and a shortfall (need to boost tourists going specifically for the wine country experience).

- Positive experience with the wines is one of the leading reasons for visiting, showing that purchase from retail and tasting at wineries can be a circular reinforcement for familiarity and consumption. Additional retail distribution and promotion in California and Nevada for the larger El Dorado wineries could help recruit wine tourism and raise awareness.

- While Red Zinfandel is the variety most associated with El Dorado, it does not necessarily boost El Dorado's quality perception among Zin fans, perhaps due to intense competition from regions like Lodi, Paso Robles and Amador.

- Participation and interest in outdoor activities (more in the hiking/biking/picnic genre than organized sports like skiing and golf) are higher among El Dorado visitors and those with an interest in visiting wine regions. These activities are a much less significant part of Napa and Sonoma's appeal and may provide a way to differentiate El Dorado.

- Some of El Dorado's traits (unusual red wines, outdoor activities, port) have more appeal to wine consumers under 45. These consumers (in particular females) are also more interested in attending festivals, music and special winery events.

- Events and to a lesser extend media exposure have a significant positive correlation on quality and value ratings and specific attributes for El Dorado wines. Consideration should be given to increasing awareness and geographic breadth for wine-related events.

- Amador and El Dorado are very similar in their levels of awareness, wine ratings and attributes, although Amador usually has slightly higher levels or ratings. Perceptions of similarities between the regions are significant and in fact increase with visitation and exposure to the wines or wineries. Promotion of El Dorado appears to boost Amador perception, and it is fair to presume the reverse is true. Therefore it may be possible create synergy by pooling resources and allying for events or promotions that benefit both regions.

Survey Results

Respondent profile

The following section gives the demographic and wine drinking profile for the survey sample.

Age	% Respondents
Under 21 (*disqualified*)	0%
21 to 24	1%
25 to 34	15%
35 to 44	19%
45 to 54	23%
55 to 64	22%
65 to 74	16%
75 or older	3%

Compared to national norms established by the WMC research, the millennial generation is considerably under-represented (18-19% vs. 33%) in the sample, while all other generations are slightly over-represented. This may reflect in part the screening out of those with household incomes under $50,000. While there were no dramatic differences between age groups in the survey results, a few are worth highlighting.

Those under 45 years old drink red blends, port, Barbera and rosé somewhat more frequently, and they are less familiar with El Dorado as a wine region.

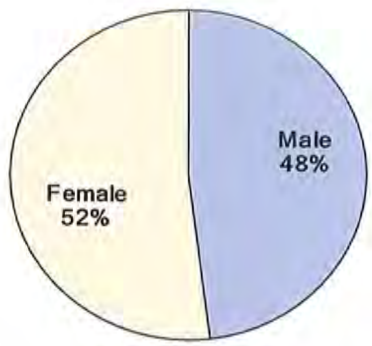
Consumers under 35s are somewhat more likely to think El Dorado wines are widely available and reliable in quality.

Wine region visitors aged 25-35 are significantly more interested in events, concerts, meeting the winemakers, and festivals.

Respondents aged 35-54 drank Red Zinfandel more frequently than other age groups, while those 45+ drink more Chardonnay.

Consumers aged 55+ are less interested in shopping and outdoor activities and more likely to see overlap between Sierra Foothill regions.

Gender



The gender breakdown of respondents was 52% female, 48% male, exactly in line with the Wine Market Council's national tracking survey. Cross-tabulation of the responses by gender revealed some significant differences:

Males consumed wine priced at $30+/bottle (off-premise retail) more frequently; 9% of them weekly or more often vs. 3% of females. However, it should be noted that this may be driven by income, as male incomes are higher than female on average.

Females are more likely to rarely or never drink Barbera, Syrah, Petite Sirah, Red Zinfandel and Port. On the other hand, they are also slightly more likely to be high frequency Red Zinfandel drinkers. Males drink somewhat more Cabernet, Merlot, Petite Sirah and Syrah.

Males were more likely to associate El Dorado with big red wines and natural beauty.

When it comes to wine tourism, females were more interested in hiking or picnicking, shopping and most social events (wine festivals, sit-down tastings, concerts/music events, VIP evenings or dinners at wineries). They were also more in visiting small unique wineries, whereas males were more interested in family wineries.

Males report higher familiarity, and are more likely to have visited the El Dorado wine region. They are also more likely to see Amador and El Dorado as similar.

Level of Education

Education Level	% Respondents*
Did not finish high school *(disqualified)*	0%
High school graduate *(disqualified)*	0%
Attended college	10%
Two year college/associate degree	9%
Graduated from a four year college	54%
Attended graduate school	5%
Earned graduate degree	22%
Prefer not to answer	0%

*graduate students/degrees weighted to reflect national norms

As is typical of regular wine consumers, the level of education was higher than the population average. Over ¾ hold college degrees and about ¼ have some exposure to graduate school.

Household Income

Household Income bracket	% Respondents
0--$24,999 *(disqualified)*	0%
$25,000--$49,999 *(disqualified)*	0%
$50,000--$74,999	18%
$75,000--$99,999	22%
$100,000--$124,999	15%
$125,000--$149,999	12%
$150,000--$174,999	7%
$175,000--$199,999	4%
$200,000 and up	11%
Prefer not to answer	10%

The distribution of income in the sample was skewed somewhat higher than WMC norms for core wine drinkers, with no representation under $50,000 annual household income, and roughly twice the percentage of people over $150,000 household income. However, it should be kept in mind that those under $50,000 annual HHI were screened out from the sample, in order to match the criteria for the 2013 data. The proportion between $50k and $150k is quite similar to national norms for wine drinkers.

Geography

Respondents were recruited to quotas for each of the states, so the sample is not proportionately representative of the state populations. The breakdown by state is close to the 75-25 target set at the start of the survey. Note that this is still somewhat skewed towards Nevada compared to the state total consumption of wine, which runs more like 90% to 10%, California vs. Nevada.

State	% Respondents	Count
California	76%	883
Nevada	24%	274

Respondents were also asked for their city and county of residence. For analysis, the respondents were then grouped into the following regions, based roughly on distance from El Dorado wine country and established markets.

Regional Distribution of Respondents

Region	% Respondents	Count
Foothills-Sacramento	9%	98
SF Bay Area	23%	259
Los Angeles to San Diego (Ventura to San Diego counties)	36%	406
Other California	10%	107
Reno (Carson City, Douglas, Lyon , Storey, Washoe counties)	7%	79
Las Vegas (Clark county)	15%	172
Other Nevada	0%	4

As determined by county, 9% of respondents come from the Sacramento or Foothills regions (Alpine, Amador, Calaveras, Colusa, El Dorado, Nevada, Placer, Sacramento, San Joaquin, Sierra, Stanislaus, Sutter, Tuolumne, Yolo counties). A further 7% are from the Reno area, thus 16% are within 2 hour or less drive from El Dorado county. Nearly one quarter (23%) are from the SF Bay area and 36% from the coastal region encompassing Ventura County, Los Angeles, Orange County and San Diego. Another 15% come from the Las Vegas area.

It should be noted that the LA-San Diego and Las Vegas regions had significantly higher proportions of under-35s (21%) while the Foothills-Sacramento region had somewhat higher population over 64. Education levels in the Nevada regions were lower than in the California regions. Household income was significantly higher in the SF Bay region.

In terms of wine consumption, the SF Bay area has significantly higher consumption of Champagne or sparkling wine and port. Consumption frequency of wine under $10 is somewhat higher in the Foothills-Sacramento area. Consumption of wines $30+ is significantly more frequent in the SF Bay area, and lower than average in the Reno region.

The closer regions of Foothills-Sacramento and Reno skew somewhat lower in their consumption of Chardonnay, and slightly higher for Barbera. Foothills-Sacramento and SF Bay regions skew higher for Red Zinfandel. The SF Bay, LA-San Diego and Reno regions all have significantly higher consumption of craft beer.

Impact of Residence by Region

In terms of familiarity with, and perception of El Dorado and its wines, the following significant differences were noted by region:

- **Quality & Value ratings** - El Dorado received its highest quality ratings in Reno (3.2), where it was tied for 2nd with Paso Robles. Second highest ratings were in the Foothills-Sacramento and LA-San Diego regions (3.0). However in Foothills-Sacramento, El Dorado trailed Paso Robles and Amador by a large margin and was slightly behind Lodi. In LA-San Diego it trailed Paso Robles considerably but was ahead of Amador and Lodi. Ratings for value followed a similar pattern, but were much more tightly clumped with fewer statistically significant differences.
- **Wine Attributes** - The closer regions of Foothills-Sacramento and Reno were much more likely to see El Dorado wines as widely available (23% and 18% vs. 4-9%); as offering great variety (31% and 29% vs. 7-12%); as being consistent and reliable in quality (25% and 21% vs. 8-13%); and as big red wines (27% vs. 8-13%). However it must be noted that residents of these same regions also had higher associations for Amador with all of these attributes, usually higher than for El Dorado.
- **Region attributes** - The same pattern was seen for attributes of the wine regions. Foothills-Sacramento and Reno residents rated both El Dorado and Amador regions as up-and-coming, natural beauty, friendly and family-run wineries and historic sites. In most of these cases Amador had a slight lead, and both counties were ranked at or near the top tier. Unlike the wine attributes, for regional attributes Calaveras was not far behind Amador and El Dorado among residents of nearby regions.
- **Foothills-Sacramento and Reno residents** were significantly more likely to agree that they "think of…Amador and El Dorado as part of the Sierra Foothills region" (73% and 77% vs. 22-59% for other regions' residents). They were more likely to agree, but not much more likely to disagree that the two regions' wines were similar. They were less likely to be confused about locations of wineries in

the Sierra Foothills' AVAs and far more likely to disagree that the Sierra Foothills designation was too big to be useful.

- Naturally, the nearer the region, the higher the perception that El Dorado makes a good day trip. However, it is notable that even in the Reno area only 36% agreed with this statement, while in Foothills-Sacramento it was 56%. The other regions trail far behind at 13% for SF Bay, 6% for LA-San Diego and 5% for Las Vegas.

- The nearby regions consistently associated El Dorado (and Amador) with a variety of attributes (fun, romantic weekend, undiscovered jewel, fun for the family, affordable, meet the winemaker/owner). Again, Amador generally had a modest lead over El Dorado in these measures.

- The SF Bay region is significantly more likely to agree that El Dorado and Amador are "hard to get around, out of the way" compared to residents of other regions.

- Sacramento-Foothills residents are significantly more likely to agree that El Dorado and Amador need better amenities such as hotels.

Some of the reasons for visiting El Dorado also varied significantly by region of residence. "Just passing through" or "Other business or personal reasons" were significantly more important for SF Bay and LA-San Diego residents. Reno residents were significantly more likely to say they visited based on the wines they had tasted from the region, or that friends had recommended it.

Reasons for visiting El Dorado by Region of Residence

Reason for Visit	Foothills-Sacramento	SF Bay	LA-San Diego	Reno	Las Vegas	Other
Passing through on my way somewhere else	27%	**44%**	**40%**	31%	36%	**62%**
Have enjoyed wines from region	**58%**	**54%**	**47%**	**72%**	36%	**62%**
Friends recommended it	30%	26%	35%	**53%**	**43%**	**46%**
like to visit wine regions looking for interesting options	**55%**	**41%**	37%	**64%**	21%	**46%**
...read about it	33%	37%	33%	39%	**43%**	38%
Attending a special event at a winery	30%	15%	30%	14%	21%	8%
Was invited by friends	**47%**	26%	28%	**42%**	**43%**	23%
referred by a wine shop or restaurant	13%	4%	23%	3%	0%	31%
attended a local wine festival	25%	10%	26%	19%	29%	8%
other reasons (business or personal)	22%	**41%**	51%	22%	21%	46%

The leading reasons for visiting El Dorado, by region of residence were:

Foothills/Sacramento – have enjoyed the wines, like to visit interesting wine regions, was invited by friends.

Reno – have enjoyed the wines, like to visit interesting wine regions, friends recommended it.

SF Bay – have enjoyed the wines, passing through, like to visit interesting wine regions, other reasons (business or personal).

LA/San Diego – other reasons (business or personal), have enjoyed the wines, passing through.

Las Vegas – friends recommended it, read about it, was invited by friends.

When visiting El Dorado, Foothills-Sacramento residents were more likely to have visited just one winery or attend an event or festival, and less likely to have stayed in a hotel or B&B. Reno residents were more likely to have visited multiple wineries. As you'd expect, the farther the region is away from the respondent's residence, the higher the likelihood that they stayed at a hotel or B&B. There were only minor differences between regions in terms of outdoor activities or restaurants.

Wine Consumption & Purchasing

Recent Consumption of Beverages

Q5. Which of the following beverages have you personally consumed in the past month?	% Respondents
Red, white or rosé wine *(required)*	100%
Champagne or sparkling wine	47%
Port or port-style wine	17%
Distilled spirits, such as scotch or vodka	65%
Craft beer	58%
Craft spirits	13%
None of the above	0%

Those respondents drinking wine less recently than in the last month were screened out.. The typical respondent drank at least three categories in the past month. While sparkling wine consumption is common, that of port or port-style wines is much less so.

Purchasing by Price Segment

Off-Premise Retail Price Bracket	Daily	Several times a week	1-2 times a week	1-3 times a month	Several times a year	Less often or never
$9.99 and under	6%	17%	19%	21%	14%	22%
$10.00 to $19.99	3%	12%	24%	31%	21%	9%
$20.00 to $29.99	1%	4%	9%	24%	36%	26%
$30.00+	0%	1%	4%	12%	37%	45%

Nearly 1/5 of respondents rarely or never purchase wines under $10, and nearly half rarely or never buy wine over $30, while 38% of respondents consume $20+ wine at least monthly. These numbers are typical for regular wine drinkers, based on research by Wine Opinions and the Wine Market Council.

High End wine drinkers, defined as those drinking $30+ wines at least monthly, comprise 17% of the sample.

High End consumers give El Dorado wines somewhat higher quality and value ratings, but they do this for many regions. The increase in ratings does bring El Dorado closer to Amador in High End consumer eyes. High End consumers are also somewhat more likely to associate El Dorado with the availability, consistent and reliable quality, variety and big reds. More of them think of the region higher as up-and-coming with friendly, family-run wineries. They are also somewhat more likely to see Amador and El Dorado as similar, and as part of the Sierra Foothills whose wines bear similarity to one another.

However, familiarity with El Dorado is only slightly higher among High End consumers than other wine drinkers. And in fact visitation is lower (7% of High Enders have visited vs. 10% of other consumers) and their intent to visit is roughly the same.

Purchasing by Variety

Variety	Daily	Several times a week	1-2 times a week	1-3 times a month	Several times a year	Less often or never
Chardonnay	2%	10%	11%	22%	25%	29%
Viognier	0%	1%	2%	7%	21%	69%
Rosé	1%	2%	5%	10%	27%	56%
Barbera	0%	1%	2%	6%	21%	70%
Cabernet Sauvignon	2%	11%	18%	31%	23%	15%
Merlot	1%	8%	14%	27%	30%	20%
Petite Sirah	0%	2%	6%	16%	30%	46%
Syrah	0%	2%	8%	18%	32%	40%
Red Zinfandel	1%	5%	9%	21%	25%	39%
Red blends	1%	5%	14%	24%	27%	28%
Port or port-style	0%	1%	3%	8%	27%	61%

Weekly consumption is broadest for Cabernet (31%), followed by Chardonnay (23% of respondents), red blends (21%) and Merlot (23%). Consumption is lowest for Barbera, Viognier and Port (with over 60% drinking these wines very few times or never).

Red Zinfandel shows 15% weekly consumption, 36% monthly, while 39% rarely or never drink this variety.

It should be noted that consumption frequency for the less popular varieties is often somewhat overestimated by survey respondents.

Regular Red Zin drinkers (monthly+) drink both under-$10 and $20+ wines more often than the average respondent. They are more likely to be familiar with El Dorado (58% vs. 46% for other consumers); and more likely to have made repeat visits (14% vs. 8%) and plan to return (17% vs. 10%).

They are more likely to have volunteered open-end descriptions of El Dorado in question #8. (Of those who drink Red Zin 3+ times a week, 56% entered text; 48% of weekly to monthly red Zin drinkers entered text; only 31% of those who drink it less often 31% entered text.) Regular consumption of Red Zinfandel also correlates positively with a number of El Dorado attributes such as "widely available" and "big reds".

However, regular Red Zin drinkers rate El Dorado wines only slightly higher than average consumers for quality and value. The only region to jump significantly in ratings among Red Zin consumers is Lodi.

Familiarity with El Dorado and Competitors

Survey participants were asked an open-ended question: "What is the first word or phrase that comes to mind when you think of the following wine regions? If you are unfamiliar with a region or no word comes to mind, just skip it." Open-ended text boxes were provided for El Dorado, Amador, Paso Robles, Lodi, Calaveras and Sonoma.

A substantial number of respondents either did not enter a word/phrase, or entered a response like "unfamiliar" or "nothing," indicating complete lack of familiarity with the region. Nearly 1/5th of respondents (19%) offered no phrase/word for any of the regions. The proportion unfamiliar varied by region:

El Dorado - 59% are too unfamiliar to venture a meaningful word or phrase
Amador – 45% unfamiliar
Paso Robles - 22% unfamiliar
Lodi - 41% unfamiliar
Calaveras - 60% unfamiliar
Sonoma - just 4% unfamiliar

Note that while Calaveras is nearly equal to El Dorado in this measure of familiarity, a much small portion of its responses were wine-related.

For each region, the word or phrase entered was coded into groups of similar entries (for example: "gold", "gold country" and "gold mines" would be coded as "gold country"). The following tables summarize the most frequent types of responses for each region. Where two different types of responses have the same frequency, they are in the same row (e.g. Country/cowboys/farming and Sierra foothills each had 0.9% of respondents for El Dorado).

EL DORADO Responses (Coded/Categorized)	% of all respondents
Unsure, unfamiliar	3.8%
Gold country	3.6%
California	3.0%
Mountains/hilly	2.6%
Hispanic connections (Mexico, Spain, etc.)	1.7%
Zinfandel	1.5%
Generic positives (favorite, fine, etc.)	1.4%
Country/cowboys/farming; Sierra foothills	0.9%
Red, red wines	0.8%
Close/local; Friendly/fun	0.7%
Delicious/ripe/yummy	0.6%
Negatives (alcohol, bitter, overrated, etc)	0.5%
Middling/OK quality; Outdoor activities; Warm/hot climate; Wineries	0.5%
Affordable/value; Fair Play	0.4%

AMADOR Responses (Coded/Categorized)	% of all respondents
Unsure, unfamiliar	4.2%
Zinfandel	3.9%
California; Red/red wine	1.5%
Generic positives (excellent, nice, etc.)	1.4%
OK, average quality	1.1%
Pretty/quaint/secluded/charming; Mountains/hilly	1.0%
Gold country; Sierra foothills	0.9%
Barbera; Trees/lakes/rural; Northern California	0.8%
Concerts, festivals, fun	0.7%
Budget/cheap; White wine; Wineries	0.5%
Flavorful, concentrated	0.2%

PASO ROBLES Responses (Coded/Categorized)	% of all respondents
California	6.0%
Red/red wine	4.8%
Generic positive (excellent, favorite, etc.)	3.3%
Pinot Noir; Zinfandel	2.5%
Central Coast	1.9%
Countryside/farms	1.8%
Unsure/unfamiliar; Up-and-coming region; Warm/hot climate; Syrah	1.5%
Close, local	1.3%
Delicious, lush	1.1%
Justin	1.0%
Rhone, GSM	0.9%
Bold, hearty; New	0.8%
OK, fair quality	0.7%
Blends; Dry; White wine; Cabernet; Fun; Grapes; High End; Merlot; Wineries	0.6%

CALAVERAS Responses (Coded/Categorized)	% of all respondents
Frog, frogs	5.8%
Unsure/unfamiliar	4.6%
California	2.6%
Frog jumping contest	1.9%
Country, rural	1.2%
Middling/OK quality; Red/red wine	1.0%
Outdoor activities, natural beauty	0.9%
Spain, Argentina; Zinfandel	0.7%
Gold country; Mark Twain	0.6%
Fairs, festivals, fun	0.5%
Mountains; Napa (contrast); Close/local; Sierra foothills; Murphys; Rich/ripe	0.4%

SONOMA Responses (Coded/Categorized)	% of all respondents
California	13.0%
Napa (mainly geographical proximity)	5.4%
High quality, excellence	3.7%
Cabernet	3.1%
Expensive, pricey	2.8%
Beautiful, scenic	2.7%
Red wine	2.6%
Chardonnay; Pinot Noir	2.3%
Generic positives (a favorite, love it, brilliant, etc.)	2.2%
Zinfandel	1.6%
Delicious; Sonoma Valley;	1.4%
Local, nearby	1.2%
Nice; White wines	1.1%
Classy, elegant	1.0%
Established/famous; Northern California	0.8%
Fun	0.7%
Peaceful, relaxing; Bold/rich/intense flavor; Variety/diverse; Smooth/mellow; Pretentious/stuffy	0.6%

LODI Responses (Coded/Categorized)	% of all respondents
Zinfandel	7.6%
California	4.6%
Unsure, unfamiliar	3.8%
Cheap/jug/bulk wine	3.4%
Warm/hot climate; Middling/OK quality	1.8%
Country, Farmland	1.6%
Social negatives (bikers, drugs, etc); Red/Red wine	1.2%
Delicious/tasty; Close/local; that Creedence Clearwater song	1.1%
Central Valley; Dry	0.9%
Up and coming region; Lesser/poor quality	0.8%
Robust/fruit bomb/bold flavor; New; Northern CA	0.7%
Sacramento; White wines	0.6%
Grapes; Old vines	0.4%

Quality and Value Ratings of El Dorado wine

Respondents were asked to rate the quality and value-for-the-money of wines from several wine regions, on a five point scale ranging from "poor" to "one of the best". They were also given the option of choosing "not familiar", if they felt they were too unfamiliar with the wines to rate them.

Ratings of El Dorado Wines vs. Competition

QUALITY	One of the best	Excellent	Good	Fair	Poor	Not familiar
El Dorado	1%	7%	19%	9%	0%	64%
Amador County	3%	9%	19%	7%	1%	61%
Paso Robles	8%	25%	33%	5%	1%	28%
Lodi	1%	8%	25%	15%	3%	48%
Calaveras	1%	5%	19%	8%	1%	67%
Sonoma	23%	43%	24%	3%	0%	7%

Value for the money	One of the Best	Excellent	Good	Fair	Poor	Not familiar
El Dorado	1%	6%	20%	8%	0%	65%
Amador County	2%	7%	21%	8%	1%	61%
Paso Robles	4%	18%	37%	11%	1%	29%
Lodi	1%	9%	30%	11%	2%	47%
Calaveras	1%	5%	20%	7%	1%	67%
Sonoma	9%	21%	45%	14%	2%	9%

The three foothill regions are far less familiar to respondents than Paso Robles, Sonoma and Lodi. Roughly 2/3 were not comfortable rating them for quality or value, whereas over half rated Lodi, over 2/3 rated Paso Robles and over 90% rated Sonoma.

Average Ratings (where "One of the best = 5, Poor = 1; "Not Familiar" removed)

Region	Quality	Value
El Dorado	3.00	3.00
Amador County	3.15	3.03
Paso Robles	3.47	3.18
Lodi	2.79	2.92
Calaveras	3.00	3.00
Sonoma	3.92	3.23

Sonoma had by far the highest quality rating, and was statistically tied with Paso Robles for the highest value rating.

El Dorado lags Amador for quality rating, but the statistical significance is borderline. It is tied with Calaveras. All three foothill regions are tied for value. Lodi lags all regions for quality, but is statistically tied with the foothill regions for value. Lodi has a significantly higher proportion rating it just "fair" for quality.

The value ratings are clustered more tightly than quality ratings. Sonoma drops to a statistical tie with Paso Robles for value, and Amador, El Dorado, Calaveras and Lodi are all statistically tied and quite close to Sonoma/Paso.

Almost no one rates any of the regions "poor" for either quality or value. In fact, only small minorities rated any regions less than "good" for quality or value. This is fairly typical of the current attitude of frequent wine consumers, based on other research. Consumers are for the most part very happy with the wines available, and competition is very keen.

Among the foothills regions, Calaveras had the highest proportion "not familiar" and Amador County the lowest, but the three regions were quite close, ranging from 61% to 67%. In contrast, about half were too unfamiliar with Lodi to rate, slightly more than ¼ too unfamiliar with Paso, and over 90% were familiar with and rated Sonoma.

Image & Attributes of El Dorado wine

Respondents were asked a series of questions about whether they associated certain attributes or features with various regions or their wines.

Q10. Please check any of the following attributes that you associate with that region's wines. If you are unfamiliar with the wines of a region, just leave its column blank.

Attributes	Sonoma	Amador County	El Dorado	Calaveras	Lodi
Wines are widely available	73%	10%	8%	7%	19%
Offers a great variety of wines worth trying	71%	16%	12%	9%	14%
Consistent and reliable quality	72%	14%	13%	7%	14%
Hard to find wines	25%	12%	9%	10%	7%
Big red wines	56%	15%	12%	9%	17%
White wines	53%	9%	7%	7%	10%

While only 8% say El Dorado wines are widely available, just 9% say they are hard to find. This is explained by the fact that the vast majority of respondents (72%) felt they were so unfamiliar with El Dorado wines that they could not even offer an opinion. In other words, among those who did rate them 29% felt they were widely available and 32% thought they were hard to find. On the other hand, 42-46% of those who did have an opinion felt El Dorado offered great variety, consistent quality and big red wines.

Amador has slightly more defined associations than El Dorado, primarily due to greater number willing to state an opinion. Calaveras is slightly less defined than El Dorado.

Lodi has higher proportions calling the wines widely available and associating it with big red wines. However, proportionate to the (higher) number who are familiar enough with Lodi to offer an opinion, Lodi's attributes are not stronger than Amador or El Dorado.

Nearly ¾ say that Sonoma wines are easy to find and in great variety, only ¼ thinking it difficult. It is associated roughly equally with red and white wine.

Q11. Please check any of the following attributes that you associate with that wine region. If you are unfamiliar with a region, just leave its column blank.

Attribute	Sonoma	Amador County	El Dorado	Calaveras	Lodi
Is an up and coming wine region	16%	18%	14%	11%	20%
Natural beauty	**72%**	25%	22%	20%	*9%*
Friendly, family run wineries	**90%**	44%	39%	34%	32%
Fun small towns	**46%**	25%	21%	20%	15%
Historic sites	**45%**	19%	24%	19%	*8%*
Gold country	13%	24%	**32%**	18%	*5%*

Sonoma is clearly ahead in natural beauty, friendly family wineries, fun small towns and historic sites. It has significantly lower ratings (especially as a proportion of those familiar) for up-and-coming and gold country.

El Dorado leads all regions in association with "Gold Country" and has a slight (borderline significant) lead over Amador and Calaveras for historic sites. Amador has significantly higher attribute associations as a region than El Dorado for up-and-coming and borderline significantly higher rating for friendly family wineries. Calaveras lags El Dorado and Amador in most of the attributes. When you consider El Dorado's lower overall familiarity, it seems that among those who know the region, El Dorado has a somewhat more defined appeal for these visitation attributes.

Lodi has higher recognition as up-and-coming, but low association with beauty, history or gold country.

Wine Tourism

In general, how often do you visit wine producing regions?

Frequency	Response Percent
Every two or three weeks or more often	3%
About once a month	7%
Every two or three months	14%
A couple of times a year	24%
About once a year	21%
Rarely *(skipped past wine tourism questions)*	26%
Never *(skipped past wine tourism questions)*	6%

Nearly 1/3 of respondents rarely or never visit wine regions, and are thus not susceptible to the loyalty and image built on wine tourism. About ¼ are regular wine country visitors, and 10% could be considered wine tourism "fanatics", visiting wineries on a monthly basis. 45% of respondents visit about 1-3 times a year.

Those who indicated they visited wine regions at least annually continued to the next question, on wine country activities.

Q13. Please indicate your degree of interest in these wine country activities:

Answer Options	Very Interested	Somewhat Interested	Not very interested	Not at all interested
Visiting small family-owned wineries	55%	41%	4%	1%
Discovering small unique wineries...	53%	38%	6%	2%
try-buy small-production wines only	45%	41%	11%	3%
Tasting as many different wines as	43%	43%	12%	2%
Picnicking, hiking or other outdoor	41%	41%	15%	4%
...exclusive sit-down tastings or food	34%	41%	20%	4%
Musical events or concerts at wineries	33%	41%	23%	3%
Meeting winery owners or winemakers	31%	42%	24%	4%
Attending wine-related festivals or	31%	45%	21%	4%
Learning about vineyard practices and	30%	49%	17%	4%
Shopping in interesting local boutiques	29%	40%	25%	6%

At least 2/3 of respondents were interested in every single activity mentioned.

Over 90% are at least somewhat interested in visiting small family-owned wineries and discovering unique wineries unknown to most other people.

Over 80% are at least somewhat interested in trying and buying small-production wines, tasting as many different wines as possible, and picnicking, hiking or other outdoor activities.

Special VIP dinners and shopping had the greatest levels of disinterest, at about 1/3 of respondents each.

Q14. Which of the following statements best describes your visitation experience with the following wine regions? Note that you may check more than one column for a region, if appropriate.

Region	Not Familiar with wines from this region	Familiar with this region, but have never visited	Have visited region, but not in past 12 months	Have visited region in past 12 months	Have visited more than once	I plan to visit or return to this wine region
Amador County	49%	16%	17%	11%	10%	13%
El Dorado	49%	17%	18%	9%	8%	11%
Lodi	36%	26%	20%	9%	9%	10%
Calaveras	55%	19%	13%	7%	7%	9%
Mendocino	25%	25%	27%	10%	13%	18%
Sonoma	4%	9%	31%	24%	37%	37%

Note that the first four columns do not add up to 100% because some respondents chose the fifth column "have visited more than once" in place of the other two visitation columns.

Among those who travel to wine regions, Calaveras has the lowest level of familiarity, while Amador and El Dorado are tied at 49% "not familiar". Familiarity with Sonoma is nearly universal, while ¾ are familiar with Mendocino and almost 2/3 with Lodi.

Visitation levels among these wine tourists were 87% for Sonoma, and 50% for Mendocino. The other regions were all well below 50%, with Lodi at 38%, Amador at 35%, El Dorado at 34%, and Calaveras at 26%.

Among those who had visited, the highest intent to return was for Sonoma at 43%. Intent to return for El Dorado was 24% returning tourists, and in fact all the other regions were clumped together from 23% (Lodi) to 29% (Amador).

The highest rate for planning a future visit was Sonoma with 37%, followed at a distance by Mendocino at 18%. All other regions were statistically tied.

Visitors to El Dorado have the following statistically significant differences from non-visitors:

- They are less likely to be 35-44 (15% vs. 22% for non-visitors); this is even more true for those who visited multiple times (9%). They are more likely to be 55+ (46% vs. 38%).
- They are more likely to come from Foothills-Sacramento or Reno regions, significantly less likely to come from LA-San Diego or Las Vegas. Multiple visits skew towards Sacramento-Foothills residents.
- They consume wines priced between $10 and $30 somewhat more often. They are more likely to consume distilled spirits and craft beer.
- They consume Chardonnay, Rosé, Barbera, Petite Sirah, Syrah, Red Zin, Port and Red Blends somewhat more frequently than other consumers.
- They rate El Dorado quality and value much higher than non-visitors (see table below). They also rate Amador and Calaveras quality and value significantly higher, as well as Lodi for value.

Selected Quality and Value Ratings by Visitation Status

Rating	Visited El Dorado	Not Visited	Multiple Visits to El Dorado
Quality			
One of the best	2%	1%	5%
Excellent	23%	3%	40%
Not familiar	11%	73%	5%
Mean rating	3.1	2.8	3.4
Value			
One of the best	3%	0%	5%
Excellent	18%	3%	31%
Not familiar	12%	74%	5%
Mean rating	3.1	2.8	3.4

Visitation dramatically boosts the association of El Dorado with all of the various wine and wine region attributes of Q10 and Q11. In particular, "a great variety of wines" jumps from 4% to 41%, "consistent and reliable quality" from 5% to 38%, "big red wines" from 6% to 37%, "up and coming wine region" from 9% to 41% (tied with Amador for 1st), "natural beauty" from 14% to 62% (1st place), and "historic sites" from 18% to 54%.

Visitation also significantly boosts association of El Dorado with all the attributes in Q16, but this includes some negative ones such as "hard to get around" and "needs better amenities such as hotels."

Q15. Please indicate if you agree, disagree or are neutral/undecided about the following statements. (BASE: those who visit wine regions at least yearly)

Statement	Agree	Neutral/ Undecided	Disagree
I think of counties like Amador and El Dorado as part of the Sierra Foothills region.	50%	47%	3%
In terms of wine, the Amador and El Dorado regions are very similar.	20%	74%	5%
I don't think I could tell you for sure if a winery was in Amador, El Dorado or some other county in the Sierra Foothills region.	45%	43%	12%
The Sierra Foothills is too big a region to be much use when choosing a winery or wine.	13%	62%	25%
Wines from the Sierra Foothills region have a lot of similarity, regardless of which county they are from.	17%	72%	11%

There were high levels of agreement with the notion that Amador and El Dorado are part of the Sierra Foothills and confusion over whether a foothills winery would be in Amador, El Dorado or elsewhere. Nearly as many people were neutral or undecided on these statements and few disagreed.

There was very high level of uncertainty on whether Sierra Foothills wines had a similar style (72% unsure) or was too big a region to be helpful (62%). One quarter of respondents disagreed that the Sierra Foothills region was too big to help them choose wines or wineries.

Moreover, there was great uncertainty as to whether Amador and El Dorado wines were similar, nearly ¾ being unsure. However, 20% agreed with this statement whereas only 5% disagreed.

Interestingly, visitation boosts more strongly the perception of El Dorado as part of the Sierra Foothills region and similarities with other Sierra wines and Amador, than it does separation and distinction from Amador and other Sierra Foothill regions.

Q16. Which of these statements best describes visiting these wine producing regions? Check as many boxes as you think apply to each region. (Base: visit wine regions at least yearly)

Answer Options	Sonoma	Amador County	El Dorado	Calaveras	Lodi
Good for a day trip	**50%**	20%	18%	13%	18%
A romantic weekend	**72%**	19%	14%	14%	7%
Fun and unpretentious	31%	26%	24%	19%	19%
Undiscovered jewel	*8%*	23%	19%	17%	11%
A fun weekend for the family	**41%**	19%	18%	16%	8%
Affordable, not expensive	22%	30%	26%	20%	33%
No tasting room fees	9%	16%	15%	10%	10%
Often meet the owners or winemaker	26%	20%	19%	*12%*	*13%*
Hard to get around, out of the way	9%	16%	16%	17%	11%
Great food	**71%**	12%	9%	8%	7%
Needs better amenities such as hotels	*7%*	16%	15%	13%	19%
Good shopping	**51%**	9%	8%	6%	5%
Luxury accommodations	**65%**	5%	6%	4%	3%

Even allowing for its higher familiarity, Sonoma holds enormous leads over the other regions on features such as great food, good shopping, a romantic weekend and luxury accommodations. It also holds a significant lead for a fun weekend with the family.

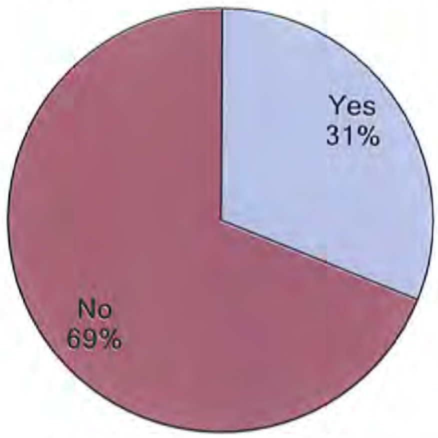
Over half (57%) of respondents checked at least one attribute for El Dorado; over ¾ of those checked two or more attributes, indicating at least reasonable familiarity. El Dorado is competitive on such features as fun and unpretentious, affordability, meeting the owners, and undiscovered jewel. However, it also rates among the highest for being hard to reach or get around, and needing better amenities.

The ratings for Amador and Calaveras are very similar to El Dorado, with Amador rating slightly higher on most features (positive and negative), probably just a result of its higher familiarity.

Lodi has higher association than other regions with affordability but also needing better amenities.

El Dorado Visitation Drivers and Activities

Q17. Have you ever visited the El Dorado wine region?



Among those who visit wine regions at least annually, over 2/3 have not visited El Dorado. Those who had visited El Dorado were passed onto the next questions about their activities in El Dorado county and what brought them there.

Q18. Have you ever heard of, or attended, any of the following wine-related events? Or have you read or viewed any of the following media about El Dorado wine country? Please check each row as appropriate. (BASE: those who visit wine regions at least yearly & have visited El Dorado)

Event/Media	Attended	Heard of, not attended	Read about or viewed	Never heard of, or read/seen
El Dorado Passport Wine Event	13%	44%	11%	32%
Nevada Day Weekend	11%	27%	9%	54%
Concert at an El Dorado winery	14%	33%	10%	43%
Harvest celebration at an El Dorado winery	13%	34%	12%	41%
Article in San Francisco Chronicle or SFGate.com	6%	15%	23%	56%
TV or online video travel piece	3%	13%	19%	66%
Article or feature in Touring & Tasting magazine (at hotels, information desks)	7%	15%	23%	54%
Article in other magazine or paper	4%	14%	21%	61%

Roughly equal proportions attended the Passport event, Nevada Day Weekend, or a concert or harvest celebration at an El Dorado winery.

Only 1/3 said they had not heard of the El Dorado passport wine event, but it should be noted that this is among consumers who **have visited** the El Dorado wine region. More than half of all respondents had not seen or heard of any of the media coverage of El Dorado.

The actual proportions of those attending or exposed may be smaller than indicated by this question – a suspicious 3-7% checked "attended" for media exposure, where it really didn't apply.

Q19. Thinking about your experience with the wine regions below, how did you happen to visit those particular regions? Please check any or all that apply. If you have not visited a region, just leave the column blank. (BASE: those who visit wine regions at least yearly & have visited El Dorado)

Reasons	El Dorado	Amador County	Lodi
Passing through on my way somewhere else (Tahoe, Sacramento, etc.)	37%	27%	24%
Have enjoyed wines from region	55%	50%	33%
Friends recommended it	35%	38%	18%
I like to visit wine regions and was looking for interesting options	47%	44%	23%
I read about the region or the wineries in the region	36%	36%	27%
Attending a special event at a winery	20%	15%	13%
Was invited by friends	33%	30%	15%
I was referred by a wine shop or restaurant	10%	14%	7%
I attended a local wine festival	19%	16%	9%
Was in the area for other reasons (business or personal)	33%	27%	19%

Respondents were asked more specifically what (if any) visitation or activities they had done in three distinct wine regions.

The leading reason for visiting any of the wine regions mentioned was previous enjoyment of the wines. Thus to some extent, introduction to the wines via retail or restaurant may prompt or influence visitation.

Nearly half of El Dorado visitors are wine tourists in general, and were looking for something new or interesting.

"Just passing through" (37%) was tied with "read about it" (36%) and ahead of referrals or invitations from friends. If you add those who checked "passing through" and those who checked "other reasons", they come to 53% of El Dorado visitors. So over half of the visitors to El Dorado have other reasons to be there, or added the winery visit as a side trip.

NOTE: The raw data tabulated above includes results for visitors of El Dorado who have not visited Amador or Lodi, hence underestimating their reasons for visiting those regions. The table below rebases Amador and Lodi so they can be compared with El Dorado.

Q19 Reasons for visitation (Amador and Lodi rebased to include only those who have visited them).

Reason	El Dorado	Amador Cty	Lodi
Have enjoyed wines from region	55%	58%	49%
like to visit wine regions, looking for interesting options	45%	51%	34%
...read about it	39%	42%	54%
Passing through on my way somewhere else	38%	31%	35%
Friends recommended it	33%	44%	26%
Was invited by friends	32%	35%	22%
other reasons (business or personal)	32%	31%	28%
Attending a special event at a winery	21%	17%	19%
attended a local wine festival	17%	19%	13%
referred by a wine shop or restaurant	11%	16%	10%

Reasons for visiting El Dorado and Amador are very similar. However, El Dorado visitors are more likely to be passing through (borderline significance), and Amador more likely to have been recommended by friends.

Lodi visitors are significantly less likely to be regular wine tourists "looking for interesting options" or be invited by friends to Lodi. They are less likely to have enjoyed wines of the region or be referred by a wine shop or restaurant, although these are not quite statistically significant.

Q20. When visiting the El Dorado wine region, what did you do on that trip?
(BASE: those who visit wine regions at least yearly & have visited El Dorado)

Activity	% Respondents
Skied	8%
Camped	13%
Other outdoor activities such as hiking or biking	24%
Stayed in a hotel or bed and breakfast	35%
Ate at gourmet restaurants	18%
Played golf	6%
Visited one winery	32%
Visited multiple wineries	59%
Attended a wine event or festival (please specify below)	15%

Although there were some open-end comments on how separated wineries were, or remoteness of the region, most visitors managed to visit multiple wineries.

However, it's notable that only about 1/3 of visitors stayed in a hotel or bed and breakfast. And reinforcing the findings of Q16, less than 1/5th reported eating at gourmet restaurants. General outdoor activities such as hiking or biking were engaged in significantly more than more upscale and formal activities such as skiing or golfing.

Only 15% of visitors were there as a result of an event or festival. Among them, 30 out of 35 entered text describing the event: Wine Event/Festival specified (30/35 entered text):
--8 attended the Passport event;
--4 visited Apple Hill;
--2 each attended the Amador County Fair or a winery release party.

The rest were single mentions ranging from Nevada day to a crab feed to a car show.

<u>Open-End Comments & Opinions on El Dorado Wine</u>

Respondents were asked one final, open-ended question: "Q21. Please share, in a few words or sentences, any experience or opinion you have on wines or wineries of El Dorado, or visiting the region. If you are completely unfamiliar with the wines or region, skip this question."

The comments entered in the text box were coded for theme and content, and are summarized below.

Category of Comment	Details	Number
Positive	60 respondents focused on the joys of visiting - at least 18 mentioned friendly staff, 11 or more the natural beauty of the region, and 9 talked about fun, adventure and other activities in the area. 21 respondents mentioned characteristics of the wines - interesting, new, fun to try, local, Zin and Barbera. 6 respondents emphasized the high quality.	97
Mixed	8 comments on visiting, positive on wines/wineries but several say it's too remote. Some say quality mixed but improving. Couple comments on wines/wineries being hard to find.	12
Neutral	mixed bag, with 3 respondents describing being in El Dorado county for other reasons, and 2 commenting on how little known the region or its wines are.	10
Negative	4 focused on quality - alcoholic, not as good as other wines, too variable. 2 did not enjoy their visit - pretentious and too expensive.	6

The following are some of the more interesting or indicative open-ended comments, sorted by general tone. The complete verbatim responses from all respondents are available from Full Glass Research.

Select Verbatim Responses (complete file available in Excel):

Mixed opinions
"They are not always easy to find, but worth the effort."

"Pretty scenery, but needed more of a draw to get me there directly from home."

"The region is has some lovely wines and we've found the winery staff very friendly -- but the wineries are a bit spread out and there aren't a lot of places to stop for food, gas, etc."

"A little overpriced, but in a scenic area. Wineries sometimes hard to find.
great area, love Placerville, hotels are more than adequate there, but in other close regions, bed and breakfasts are a better choice. Wineries can be challenging to find, but getting better and of course getting more expensive. Going to apple hill for the apple festival is fun too."

Negative opinions
"High alcohol"

"They just haven't been touted as being great, quite frankly, I just like a nice 8 dollar bottle of wine, If I visit the El Dorado region, it is for some other reason than for wine.

It's just not that pretty, lots of brown. It will never be a Sonoma, where the climate is different and not so brown."

"It seems like they have not figured out their region. There was a huge range of varietals and expression of those various grapes. Many were poor, most were OK, some were very good, but not many."

Neutral Observations
"less known and small wineries."

" Just stopped at a winery on a gold dust panning trip."

"The only winery I visited made only red wine and I only drink white."

Positive opinions
"They are developing into good quality wine producers."

"Enjoyed visiting a few of the wineries. Lovely countryside and some beautiful views from some of the tasting rooms."

"I take all my out of town guests to the wineries in El Dorado Co! The drive is beautiful, wines are tasty and it's much more casual than Napa. No matter what level wino you are, you feel like you can fit in at these small, family owned operations."

"Beautiful scenery, with good wines, overshadowed by the Napa/Sonoma name. I forget about it when I think of going wine tasting."

"great place to avoid the crowds and taste very good wines in a casual atmosphere"

"It is close to our area and has a good selection of wineries. Is still affordable compared to Napa."

"Our most frequently visited wine area. Enjoy tasting different wines. Friendly tasting room staffs. Have over years been in 10+ wine clubs. Currently in 3 clubs."

"I liked that the tasting rooms weren't very crowded. Staff was very friendly and approachable but still knowledgeable."

"We had no idea this area was so awesome. We really enjoyed the wines we tasted, everyone was so friendly & recommended other wineries (& a great restaurant in Tahoe). We would love to go back, there are so many more wineries to try!"

"Big region from Lake Tahoe to Sacramento, a lot of outdoor activities to do e.g. white water rafting, hiking, skiing and also activities to relax afterwards e.g. restaurants, hotels, and lodges in the back-country"

"I absolutely love this area. We are planning an American River rafting trip, camping, and wine tasting after. It is a wine region that is geared toward outdoor enthusiasts and should stay that way!! No huge chain hotels please, if that is what this survey is trying to decide."

"I thought the area was less crowded and overrun like Napa. Charming"

"Nice place to stop on a drive from Sacramento or San Francisco to Lake Tahoe."

"Love the El Dorado wineries... keep them small and friendly!"

"I have ordered wine for this region when I am in the area. I like to try local wines whenever possible. I enjoy driving through the area but have not stopped at any wineries in the area. Have purchased wine from the area when staying at family cabin in Tahoe"

"Wonderful Zinfandel and Barbera wines. A very large number of wineries can be intimidating without a plan. It has been over 5 years since I have been to El Dorado."

Impact of Event/Media Exposure

Among regular visitors to wine regions who had visited the El Dorado wine region, the following attendance at events or exposure to El Dorado-related media was reported:

Event/Media	% Exposed
El Dorado Passport Wine Event	13%
Nevada Day Weekend	11%
Concert at an El Dorado winery	14%
Harvest celebration at an El Dorado winery	13%
Article in San Francisco Chronicle or SFGate.com	23%
TV or online video travel piece	19%
Article or feature in Touring & Tasting magazine	23%
Article in other magazine or paper	21%

These respondents were grouped into those who had attended at least one event, and those who had been exposed to at least one type of media with information or promotion of El Dorado wines or wine country. Their results were compared to other, non-exposed, respondents.

First of all, it must be emphasized that 52% of El Dorado visitors who attended an event were residents of the Reno, Sacramento or foothills regions, and therefore within a relatively short drive of the El Dorado wine region. Nearly 1/3 (32%) of those exposed to

El Dorado wines via media also resided in those regions. That said, the following significant differences by event and media exposure were noted.

Quality and value ratings for El Dorado wines were significantly higher among those who had attended El Dorado events or read/viewed media on El Dorado wines.

Region	Avg. Quality Ratings (5=best...1=poor)			
	Attended Event	Did Not	Read/Viewed Media	Did Not
El Dorado	**3.4**	**2.8**	**3.2**	**2.8**
Amador	**3.5**	**3.0**	**3.3**	**3.0**
Paso Robles	3.6	3.5	3.5	3.5
Lodi	2.9	2.8	2.8	2.8
Calaveras	**3.2**	**2.8**	**3.0**	**2.8**
Sonoma	4.0	3.9	4.0	3.9

Region	Avg. Value Ratings (5=best...1=poor)			
	Attended Event	Did Not	Read/Viewed Media	Did Not
El Dorado	**3.3**	**2.8**	**3.1**	**2.8**
Amador	**3.3**	**2.9**	**3.2**	**2.9**
Paso Robles	3.1	3.2	3.2	3.2
Lodi	3.0	2.9	2.9	2.9
Calaveras	2.9	2.8	**3.0**	**2.8**
Sonoma	3.1	3.2	3.3	3.2

Note: significant differences between paired numbers indicated by bold font

Interestingly, respondents who were exposed to events or media also chose higher quality ratings on average for the other foothill regions (Amador, Calaveras); but they did not do so for Paso Robles, Lodi or Sonoma. This indicates that the exposed group was not just more enthusiastic wine consumers in general, a conclusion supported by the fact that they did not show greater interest in learning about vineyard and winemaking practices in Q13. In fact there is a genuine correlation between the exposure and the quality/value ratings for the Sierra Foothill regions.

However, those who attended events or were exposed to wine media are more opinionated and involved consumers. A higher proportion of such respondents associated the attributes in Q10 (wines are widely available, wines are hard to find, great variety of wines, consistent and reliable quality, big red wines, white wines) with all of the regions except for Sonoma.

This same phenomena was observed with Q11's attributes of wine regions, wherein El Dorado, Amador and Calaveras all had higher association with "up-and-coming", "natural beauty", "friendly & family run wineries", "historic sites" and "gold country". Lodi had higher associations with all of those traits except for gold country (and was still very low for natural beauty). Sonoma did not have higher associations with any of the traits except for "historic sites" among the media-exposed.

This pattern was repeated with Q16's list of attributes associated with visiting wine regions. The event and media-exposed respondents generally had higher agreement with attributes for all foothills regions, but much fewer differences for Lodi or Sonoma. The one interesting exception was for the attribute "Hard to get around, out of the way", wherein those exposed to El Dorado events were not significantly more likely to agree although those exposed to media were.

As one would expect, those who attended El Dorado events were significantly more interested in attending wine-related festivals or events in general. They did not differ significantly from other El Dorado visitors except in somewhat greater interest in exclusive sit-down tastings and food pairings or special VIP events or dinners at wineries.

Those exposed to El Dorado through various media were also somewhat more interested in attending wine-related festivals or events.

On the subject of El Dorado's relationship with the other foothills regions, there were dramatic differences between event attendees or those exposed to El Dorado through the media and other El Dorado visitors. These two groups were more opinionated on the subject and far less likely to be neutral.

Statement	AGREE		DISAGREE	
	Event or Media-exposed	Others	Event or Media-exposed	Others
I think of counties like Amador and El Dorado as part of the Sierra Foothills region.	78%	45%	5%	3%
In terms of wine, the Amador and El Dorado regions are very similar.	39%	16%	15%	5%
I don't think I could tell you for sure if a winery was in Amador, El Dorado or some other County in the Sierra Foothills region.	30%	46%	31%	8%
The Sierra Foothills is too big a region to be much use when choosing a winery or wine.	16%	12%	49%	23%
Wines from the Sierra Foothills region have a lot of similarity, regardless of which Cty they are from.	29%	15%	25%	9%

Those who attended events were much more likely to think of Amador and El Dorado as part of the Sierra Foothills region. They were also twice as likely to believe that Amador and El Dorado wines are similar, but also more likely to disagree with that statement. The same goes for the statement that Sierra Foothills wines have a lot of similarity between the. They were far more likely to disagree that they were confused by winery locations in the Sierra Foothills and that the Sierra Foothills was too big a region to be of much use. The same patterns were observed of those who were exposed to El Dorado through the media.

In conclusion, those who attended El Dorado events and were exposed to El Dorado through the media are more engaged wine consumers in general, and have formed a clearer picture or have greater involvement with the Sierra Foothills as a wine region. This aligns with their higher likelihood of residing in the region or nearby.

Comparison to 2013 Survey Results

As stated in the introduction, the consumer sample for 2015 was recruited from the same source as the 2013 study, with the same criteria. Unfortunately, neither the raw data nor the topline results for each question were available for the 2013 study, only select data presented in a report and meeting.

The demographic and wine drinking characteristics of the 2015 study respondents closely paralleled the available data from 2013, with two exceptions: the ratio of California to Nevada residents, and education, where the 2015 respondents showed a significantly higher proportion with a graduate degree. The ratio of California to Nevada residents was deliberately changed to better match the actual market for El Dorado wineries.

Therefore, when comparing the 2015 and 2013 results, the 2015 data was weighted by state and education level to control for these differences and provide a more meaningful comparison.

However, only some questions from the 2013 study were retained for comparison. And in some cases, incomplete data from the 2013 study or revisions to question placement make the data impossible to compare, or make conclusions on the differences tentative.

For example, in the open-end question on word associations with El Dorado, we don't know how Stonebridge coded these entries under "Spontaneous Phrases." Most of the associations that are word-for-word comparable between 2013 and 201 5 (Gold country, red wines, Sierra Foothills, Hispanic connections) were also prominent in both surveys but declined in 2015. On the other hand, there appeared to be greater diversity of positive comments in 2015 than was coded as "quality" in 2013 (fine, delicious, yum, favorite, etc.) The proportion "unfamiliar" from 2015 is roughly similar to 2013, but whether it slightly increased or slightly declined depends on how blank or "na" type responses were coded in 2013.

Similarly, the report only delivered the top five chosen for each region among the listed attributes, so it is not possible to compare 2013 vs. 2015 for any of the other attributes. In addition, the attribute lists were shorter to both improve respondent attention and allow room for other questions.

Comparison of 2015 weighted and 2013 samples

Sample attribute	2015 weighted	2013
Gender		
Male	47%	46%
Female	53%	54%
State		
California residents	56%	54%
Nevada residents	44%	46%
Education/Income		
College degree	78%	75%
Graduate degree	22%	21%
Over $50k Household Income	100%	100%
Consumed in past month...		
Red/white/rose wine	100%	100%
Champagne or sparkling wine	45%	47%
Distilled spirits	65%	66%
Craft beer	57%	48%

With those caveats in mind, the following differences were noted between 2013 and 2015 results.

- Association of El Dorado as an "up-and-coming" wine region decreased from 23% to 14%; association of El Dorado with "friendly, family-run wineries" increased from 20% to 37%.
- Perception that Sonoma wines were widely distributed increases from 54% to 79%.
- Association of Amador with a "great variety of wines" increased from 21% to 23%, while association of Amador with white wines declined 33% to 12%.
- Characterization of Lodi as an "up-and-coming" wine region declined 28% to 17%.
- Although the measures were not directly comparable, it is clear that the number of respondents who visit wine regions and their frequency of visitation increased moderately.
- The proportion of those who characterized the El Dorado wine region as "hard to get around, out of the way" declined from 22% to 15%.
- The proportion of respondents who associated El Dorado with good food, shopping, and luxury hotels increased moderately from low levels (7% to 10%, 4% to 8%, 2% to 6% respectively).

Visitation to various wine regions 2013 vs. 2015

	Not familiar with wines from this region		Familiar, have not visited		Visited, not in past 12 months		Visited in past 12 months	
Region	**2013**	**2015**	**2013**	**2015**	**2013**	**2105**	**2013**	**2015**
Amador	60%	50%	20%	19%	10%	18%	10%	13%
El Dorado	55%	52%	25%	17%	13%	19%	7%	12%
Lodi	43%	39%	32%	28%	16%	22%	8%	10%
Calaveras	56%	58%	26%	21%	12%	15%	5%	6%
Sonoma	5%	6%	18%	11%	40%	46%	36%	37%

Familiarity and visitation increased for all regions in the Q14 list except for Calaveras (Mendocino not included in the table because it was not in the 2013 survey). However, the increases in familiarity with Sonoma (already nearly universal), and recent visitation to Sonoma, were not statistically significant.

El Dorado's increase in familiarity lagged Amador, but its increase in visitation was proportionally equivalent. Although Calaveras did not increase its familiarity, those who were aware were more likely to have visited by 2015.

Appendix - EDWA 2015 Consumer Survey Questionnaire

Q1.In what state or U.S. territory do you live?
(Drop-down box with all 50 states + DC + Other-please specify)
(Residents of all states except CA and NV are disqualified)

2. Please enter the town and county where you live.
Town/City:
County:
(Two open-end boxes)

3. What is your gender?

Male
Female

4. What is your age?
Under 21 *(Disqualifies)*
21 to 24
25 to 34
35 to 44
45 to 54
55 to 64
65 to 74
75 or older

5. Which of the following beverages have you personally consumed in the past month? (Please select all that apply.)
Red, white or rosé wine *(Only those checking this box continue; all others disqualified)*
Champagne or sparkling wine
Port or port-style wine
Distilled spirits, such as scotch or vodka
Craft beer
Craft spirits
None of the above

6. In general, about how often do you personally consume wine in each of the price segments listed below?

	Daily	Several times a week	1-2 times a week	1-3 times a month	Several times a year	Less often or never
Under $9.99						
$10.00 to $19.99						
$20.00 to $29.99						
$30.00+						

7. In general, about how often do you personally consume each of the types of wine listed below?

	Daily	Several times a week	1-2 times a week	1-3 times a month	Several times a year	Less often or never
Chardonnay						
Viognier						
Rosé						
Barbera						
Cabernet Sauvignon						
Merlot						
Petite Sirah						
Syrah						
Zinfandel						
Red blends						
Port or port-style wines						

8. What is the first word or phrase that comes to mind when you think of the following wine regions? If you are unfamiliar with a region or no word comes to mind, just skip it.

El Dorado *(Open-end text box)*
Amador County *(Open-end text box)*
Paso Robles *(Open-end text box)*
Lodi *(Open-end text box)*
Calaveras *(Open-end text box)*
Sonoma *(Open-end text box)*
(Region Order randomized)

9. Please rate the quality and the value for the money of wines from each of the following regions. If you are undecided or unfamiliar with the wines of a region, just check "Not familiar". *(Two drop-down boxes, each with the following scale: One of the Best…Excellent…Good…Fair…Poor… Not familiar)*

	Quality	**Value**
El Dorado		
Amador County		
Paso Robles		
Lodi		
Calaveras		
Sonoma		

(Region Order randomized)

10. Please check any of the following attributes that you associate with that region's wines. If you are unfamiliar with the wines of a region, just leave its column blank.

	Sonoma	Amador County	El Dorado	Calaveras	Lodi
Wines are widely available					
Offers a great variety of wines worth trying					
Consistent and reliable quality					
Hard to find wines					
Big red wines					
White wines					

(Attribute order randomized except "none of the above")

11. Please check any of the following attributes that you associate with that wine region. If you are unfamiliar with a region, just leave its column blank.

	Sonoma	Amador County	El Dorado	Calaveras	Lodi
Is an up and coming wine region					
Natural beauty					
Friendly, family run wineries					
Fun small towns					
Historic sites					
Gold country					

(Attribute order randomized except "none of the above")

12. In general, how often do you visit wine producing regions?
Every two or three weeks or more often
About once a month
Every two or three months
A couple of times a year
About once a year
Rarely *(skipped to Q20)*
Never *(skipped to Q20)*

13. Please indicate your degree of interest in these wine country activities:

	Very Interested	Somewhat Interested	Not very interested	Not at all interested
Learning about vineyard practices and how the wine is made				
Visiting small family-owned wineries				
Meeting winery owners or winemakers				
Shopping in interesting local boutiques and stores				
Picnicking, hiking or other outdoor activities				
Attending wine-related festivals or special events (e.g. "passport" weekends)				
Tasting as many different wines as possible				
Discovering small, unique wineries that most people don't know about				
Attending exclusive sit-down tastings or food pairings at a winery				
Getting to try and buy small-production wines that are only available at the winery				
Musical events or concerts at wineries				
Special or VIP evening events or dinners at the winery				

(Activity order randomized)

14. Which of the following statements best describes your visitation experience with the following wine regions? Note that you may check more than one column for a region, if appropriate.

	Not Familiar with wines from this region	Familiar with this region, but have never visited	Have visited region, but not in past 12 months	Have visited region in past 12 months	Have visited more than once	**I plan to visit or return to this wine region**
Amador County						
El Dorado						
Lodi						
Calaveras						
Mendocino						
Sonoma						

(Region order randomized)

15. Please indicate if you agree, disagree or are neutral/undecided about the following statements.

	Agree	Neutral/Undecided	Disagree
I think of counties like Amador and El Dorado as part of the Sierra Foothills region.			
In terms of wine, the Amador and El Dorado regions are very similar.			
I don't think I could tell you for sure if a winery was in Amador, El Dorado or some other county in the Sierra Foothills region.			
The Sierra Foothills is too big a region to be much use when choosing a winery or wine.			
Wines from the Sierra Foothills region have a lot of similarity, regardless of which county they are from.			

16. Which of these statements best describes visiting these wine producing regions? Check as many boxes as you think apply to each region.

	Sonoma	Amador County	El Dorado	Calaveras	Lodi
Good for a day trip					
A romantic weekend					
Fun and unpretentious					
Undiscovered jewel					
A fun weekend for the family					
Affordable, not expensive					
No tasting room fees					
Often meet the owners or winemaker					
Hard to get around, out of the way					
Great food					

Needs better amenities such as hotels
Good shopping
Luxury accommodations
(Attribute order randomized)

17. Have you ever visited the El Dorado wine region?

Yes
No *(Skip to Q20)*

18. Have you ever heard of, or attended, any of the following wine-related events? Or have you read or viewed any of the following media about El Dorado wine country? Please check each row as appropriate.

	Attended	Heard of, not attended	Read about or viewed	Never heard of, or read/seen
El Dorado Passport Wine Event				
Nevada Day Weekend				
Concert at an El Dorado winery				
Harvest celebration at an El Dorado winery				
Article in San Francisco Chronicle or SFGate.com				
TV or online video travel piece				
Article or feature in Touring & Tasting magazine (at hotels, information desks)				
Article in other magazine or paper (please specify)				

19. Thinking about your experience with the wine regions below, how did you happen to visit those particular regions? Please check any or all that apply. If you have not visited a region, just leave the column blank.

	El Dorado	Amador County	Lodi
Was in the area for other reasons (business or personal)			
Have enjoyed wines from region			
Friends recommended it			
I like to visit wine regions and was looking for interesting options			
I read about the region or the wineries in the region			
Attending a special event at a winery			
Was invited by friends			
I was referred by a wine shop or restaurant			
I attended a local wine festival			
Passing through on my way somewhere else (Tahoe, Sacramento, etc.)			
Other (please specify)			

(Reason order randomized except "other")

20. When visiting the El Dorado wine region, what did you do on that trip? Please check all that apply.

Skied
Camped
Other outdoor activities such as hiking or biking
Stayed in a hotel or bed and breakfast
Ate at gourmet restaurants
Played golf
Visited one winery
Visited multiple wineries
Attended a wine event or festival (please specify)

21. Please share, in a few words or sentences, any experience or opinion you have on wines or wineries of El Dorado, or visiting the region. If you are completely unfamiliar with the wines or region, skip this question. *(Open-end text box)*

22. What was the last grade of school you personally completed?
Did not finish high school *(Retroactively disqualified)*
High school graduate *(Retroactively disqualified)*
Attended college
Two year college/associate degree
Graduated from a four year college
Attended graduate school
Earned graduate degree
Prefer not to answer *(Retroactively disqualified)*

23. What is your approximate average household income?

0--$24,999 *(Retroactively disqualified)*
$25,000--$49,999 *(Retroactively disqualified)*
$50,000--$74,999
$75,000--$99,999
$100,000--$124,999
$125,000--$149,999
$150,000--$174,999
$175,000--$199,999
$200,000 and up
Prefer not to answer *(Retroactively disqualify? TBD)*

SCBG Taste Test Pre Student Survey

1. Circle the commodities below that are specialty crops.

- [ ] Almonds
- [ ] Rice
- [ ] Apples
- [ ] Cilantro
- [ ] Pumpkins

2. Sate 1 nutritional benefit of a specialty crop.

3. How many servings of fruits and vegetables did you eat last week?

- ○ 0
- ○ 1-2
- ○ 3-4
- ○ More than 5

4. Please list them below

5. Did you try a fruit or vegetable that was new to you in the last week?

- ○ Yes
- ○ No

SCBG Taste Test Pre Student Survey

6. What was it?

SCBG Taste Test During Student Survey

1. Circle the commodities below that are specialty crops.

- [ ] Almonds
- [ ] Rice
- [ ] Apples
- [ ] Cilantro
- [ ] Pumpkins

2. Sate 1 nutritional benefit of a specialty crop.

3. How many servings of fruits and vegetables did you eat last week?

- ○ 0
- ○ 1-2
- ○ 3-4
- ○ More than 5

4. Please list them below

5. Did you try a fruit or vegetable that was new to you in the last week?

- ○ Yes
- ○ No

6. What was it?

SCBG Taste Test Post Student Survey

1. Circle the commodities below that are specialty crops.

- [ ] Almonds
- [ ] Rice
- [ ] Apples
- [ ] Cilantro
- [ ] Pumpkins

2. Sate 1 nutritional benefit of a specialty crop.

3. How many servings of fruits and vegetables did you eat last week?

- ○ 0
- ○ 1-2
- ○ 3-4
- ○ More than 5

4. Please list them below

5. Did you try a fruit or vegetable that was new to you in the last week?

- ○ Yes
- ○ No

SCBG Taste Test Post Student Survey

6. What was it?

California Specialty Crop Taste Test Grant Pre-Survey

1. Identify a commodity below that is a specialty crop.

- ○ Almonds
- ○ Rice
- ○ Apples
- ○ Cilantro
- ○ Pumpkins

2. State one nutritional benefit of a specialty crop.

3. How will this program be beneficial to your classroom instruction?

California Specialty Crop Taste Test Grant Mid-Survey

1. Identify a commodity below that is a specialty crop.
(select all that apply)

- ☐ Almonds
- ☐ Rice
- ☐ Apples
- ☐ Cilantro
- ☐ Pumpkins

2. State one nutritional benefit of a specialty crop.

3. Are the resources that your class was provided with helpful in teaching about specialty crops?

○ Strongly agree ○ Agree ○ Somewhat agree ○ Neither agree or disagree ○ Somewhat disagree ○ Disagree ○ Strongly disagree ○ Not applicable

4. How has this program been beneficial to your classroom instruction?

Taste Test Grant POST-Survey (Teachers)

1. Identify a commodity below that is a specialty crop.
(select all that apply)

- [ ] Almonds
- [ ] Rice
- [ ] Apples
- [ ] Cilantro
- [ ] Pumpkins

2. State one nutritional benefit of a specialty crop.

3. Are the resources that your class was provided with helpful in teaching about specialty crops?

○ Strongly agree ○ Agree ○ Somewhat agree ○ Neither agree or disagree ○ Somewhat disagree ○ Disagree ○ Strongly disagree ○ Not applicable

4. How has this program been beneficial to your classroom instruction?

BestBuds

After School Nutrition Education

School Garden - *Plant, Harvest, Cook and Taste*




Head Start Program

Specialty Crop - Green Vegetables Lesson

“It is not easy being Green”


Head Start Program

Parent Nutrition Education

Students enjoying CA specialty crops in Napa thanks to Harvest of the Month!

FOTM VIDEO TRACKING 2015

		Total YouTube	VIEWS as of June 2015 Students	Assemblies
September, 2014	Grapes	144	3,456	xx
October, 2014	Peppers	288	6,912	xx
November, 2014	Spinach	405	9,720	xx
December, 2014	Mandarins	839	20,136	xx
January, 2015	Kiwi	229	5,496	xx
February, 2015	Kale	412	9,888	xx
March, 2015	Radishes*	83	3,093	xx
April, 2015	Peas	328	7,872	xx
May, 2015	Strawberries	78	1,872	xx
2014-2015 School year-to-date average as of April, 2015		311.78	7,483	
2013-2014 School year average		177.43	4,258	
Additional 2014-15 views of 2013-14 videos		144	3,468	
			15,209	Total views

*Radish video was also shown directly to x1101 attendees
at the March 6, 2015 Ag Day event at the Napa Expo Fairgrounds

Some barriers to viewing the videos include:

1. equipment presence or functionality in classrooms
2. teachers receiving the video links
3. not enough time

Student views calculated on YouTube views minus 20% for non-classroom, times 30 students per classroom

Target goal = 2045 year 1

Plus 10% = 2250 year 2

Plus 10% = 2475 year 3

NVUSD Harvest of the Month
Enrollment & Schedule 2014.15

Area	School	Phone Number	Address	Participating Enrollment	Participating Classrooms	Participating Percentage	
Tues							
	Napa Junction	707-253-3461	300 Napa Junction Road, Am Can	474	18	99	SDC not included
	Donaldson Way	707-253-3524	430 Donaldson Way, Am Can	635	23	100	
	Canyon Oaks	707-265-2363	475 Silver Oak Trail, Am Can	721	26	100	
Wed							
	Irene M. Snow	707-253-3666	1130 Foster Road, Napa	507	22	100	
	McPherson	707-253-3488	2670 Yajome Street, Napa	530	22	100	
	Phillips Charter	707-253-3481	1210 Shetler Avenue, Napa	195	7	100	
Thurs							
	Browns Valley	707-253-3761	1001 Buhman Avenue, Napa	561	21	100	
	Shearer Charter	707-253-3508	1590 Elm Street, Napa	542	29	100	
	NVLA	707-253-3678	2700 Kilburn Avenue, Napa	705	26	100	
*****	West Park	707-253-3516	2315 West Park Avenue, Napa	355	14	100	
Mon	Alta Heights	707-253-3671	15 Montecito Blvd, Napa	373	15	100	
Tues	Bel Aire	707-253-3775	3580 Beckworth Drive, Napa	460	18	100	
	Vista 360 PV	707-253-3491	1600 Barbara Road	288	12	100	
	Napa Alternative		1600 Barbara Road	12	1	100	
	Northwood	707-253-3471	2214 Berks Street, Napa	351	14	100	
Wed							
	Salvador	707-253-3476	1850 Salvador Ave, Napa	261	13	100	
******	Phillips Charter	707-253-3481	1210 Shetler Avenue, Napa	195	7	100	
Thurs							
	El Centro	707-253-3771	1480 El Centro Avenue, Napa	251	12	100	
	Mt. George	707-253-3766	1019 Second Avenue, Napa	257	10	100	
	Vichy	707-253-3544	3261 Vichy Avenue, Napa	374	14	100	
	Yountville	707-253-3485	6554 Yount Street, Yountville	123	6	100	
Wed	Phillips Charter	707-253-3481	1210 Shetler Avenue, Napa	195	7	100	
				8365	337		
			Total enrollment			99.92%	8372

Phillips school has asked for deliveries on three wednesdays.

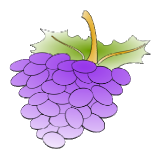
Updated Oct 27,2014

2014/2015 Sodexo Local Produce Spend

Total Fresh Point spend on produce for the 14/15 school year $401,661.34. Of that $229,185.99, or **57.06% was from locally grown produce.**

Quick Facts

1,037 cases of local apples from **Gowan Orchards in Philo, CA** in were purchased from August to December. That is 205,326 apples.



13,334 pounds of local grapes were purchased throughout the school year.

1,111 cases of local, organic strawberries were sourced from **Coke Farms in San Juan Bautista** and **Duran Growers** in **Watsonville.**

3,785 pounds of local baby spinach was served to students on salad bars.

Other Local Growers Featured in Conjunction with the HOTM Program:

Ariza Farm– Orland, CA. 54cs of Local Kiwi's purchased.

Miller Honey Farms, Newcastle, CA. 14cs of Mandarins purchased.

Capay Organics– Capay, CA.

40cs of kale purchased.

5/15 Harvest of the Month Survey Student Nutrition and Consumption k-2

1. I like to try new fruits

- ◯ almost always or always
- ◯ sometimes
- ◯ almost never or never

2. I like to try new vegetables

- ◯ almost always or always
- ◯ sometimes
- ◯ almost never or never

3. Do you eat fruits and vegetables at home?

- ◯ never
- ◯ sometimes
- ◯ always
- ◯ I don't know

4. Do you eat fruits and vegetables at school?

- ◯ never
- ◯ sometimes
- ◯ always
- ◯ I don't know

5. Do Snap peas come from California?

◯ yes

◯ no

◯ I don't know

6. Does eating fresh fruits and vegetables make you strong, healthy and smart?

◯ yes

◯ no

◯ I don't know

Done

Harvest of the Month Student Survey 3-5 May 2015

1. Did you taste Harvest of the Month (HOTM) fruits and vegetables in your classroom/school?

- ◯ yes
- ◯ no
- ◯ I don't know

2. If you tasted HOTM fruits and vegetables, have you eaten them again in your lunch at school?

- ◯ yes
- ◯ no
- ◯ I don't know

3. If you tasted HOTM fruits and vegetables, have you eaten them in your meals at home?

- ◯ yes
- ◯ no
- ◯ I don't know

4. Did you eat any vegetables yesterday?

- ◯ yes
- ◯ no
- ◯ I don't know

5. Did you eat any fruit yesterday?

- ☐ yes

☐ no

☐ I don't know

6. Did you drink 100% fruit juice yesterday?

○ yes

○ no

○ I don't know

7. The following fruits and vegetables are grown in California: Please select all that apply

☐ pears

☐ apples

☐ bananas

☐ carrots

☐ mandarins

☐ kale

☐ pineapples

☐ broccoli

☐ spinach

☐ snap peas

8. Eating fresh fruits and vegetables gives you more energy for playing

○ yes

○ no

○ I don't know

9. Eating fruits and vegetables will help me grow healthy, smart and strong

- ◯ yes
- ◯ no
- ◯ I don't know

10. I will have healthier skin if I eat fruits and vegetables

- ◯ yes
- ◯ no
- ◯ I don't know

11. I will have stronger eyes if I eat fruits and vegetables

- ◯ yes
- ◯ no
- ◯ I don't know

12. If I eat fruits and vegetables, I will be able to think better in class

- ◯ yes
- ◯ no
- ◯ I don't know

13. If I eat fruits and vegetables, I will have healthier teeth, and less cavities.

- ◯ yes
- ◯ no
- ◯ I don't know

Done

Harvest of the Month Teacher Survey 5/2015

1. Were the Harvest of the Month (HOTM) materials - Family Newsletter with lesson ideas, and the Farmer of the Month profile easy to incorporate into your lesson plans?

- ◯ yes
- ◯ no

comments

2. Were the Harvest of the Month Tasting Kits easy to use?

- ◯ yes
- ◯ no

comments

3. Which Harvest of the Month item was the most successful in your classroom

- ☐ kiwi (jan)
- ☐ kale (feb)
- ☐ radish (march)
- ☐ snap pea (april)
- ☐ strawberries (may)

Other (please specify)

4. Which Harvest of the Month item was the least successful in your classroom?

◯

- ○ kiwi
- ○ kale
- ○ radish
- ○ snap peas
- ○ strawberries

Other (please specify)

5. What were the challenges with the least successful HOTM fruit or vegetable?

6. Were HOTM lessons effective in teaching about California Agriculture?

- ○ yes
- ○ no

comments

7. Were HOTM lessons effective in teaching about nutrition?

- ○ yes
- ○ no

comments

8. Did you use the Farmer of the Month Written Profile?

- ○ yes
- ○ no

If yes, how often did you use the FOTM profile

9. Did you show your students the short Farmer of the Month (FOTM) YouTube video profile?

◯ yes

◯ no

If no, why didn't you show the video?

10. If you used the FOTM profiles, did your students learn about CA agriculture and farm production?

◯ yes

◯ no

comments

11. How much time did you spend on each month's HOTM lesson?

◯ less than 5 minute

◯ 5-10 minutes

◯ 10-20 minutes

◯ more than 20 minutes

comments

12. Would you like to plan additional nutrition and ag literacy programs with Chef Elizabeth, the Harvest of the Month Coordinator?

◯ classroom cooking lesson

◯ school tasting event/assembly

◯ garden based nutrition education

◯ other

Contact Information

13. Do you plan to participate in Harvest of the Month, next year?

◯ yes

◯ no

Other (please specify)

14. Please give us any additional feedback on your experience and recommendations to improve the program.

Done

Drying and Decontamination of Pistachios by Sequential Infrared and Hot Air Drying

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Abstract

Sorting of dehulled pistachios in water results in significant moisture gain on the nut surface. Therefore, quick drying of pistachios is vital to avoid shell staining, decay and microbial contamination. The current hot air drying practices for pistachios have low drying rates, high labor and energy inputs and do not guarantee safe products. The objectives of this research were to develop a sequential infrared and hot air (SIRHA) drying method for pistachios and evaluate its effectiveness to perform simultaneous drying and decontamination of pistachios. Dehulled and sorted pistachios obtained from the central valley of California were dried in the SIRHA dryer using different time-combinations of Infrared (IR) radiation and hot air drying to determine the optimum drying conditions. Pistachios were inoculated with Pediococcus and dried using SIRHA dryer to evaluate the decontamination effect of SIRHA drying method. The results showed that the SIRHA drying of pistachios (IR heating for 2 h at a product temperature of 70°C followed by hot air drying at 70°C) reduced the total drying time by 25.93% to dry the pistachios from the moisture content of 38.14% (w.b.) to 8.90% compared to hot air drying at 70°C. Drying of pistachios in SIRHA dryer using IR heating at 70°C for 20 min, 1 h, and 2 h and holding the pistachios at 70°C for 1h followed by hot air drying to 8.90% MC resulted in Pediococcus population reduction of 5.41, 5.60 and 6.39 log CFU/g, respectively, for pistachio kernels and 5.45, 5.42 and 5. 29 log CFU/g, respectively, for pistachio shells. No significant difference in peroxide value and free fatty acid contents was observed for the pistachios dried by SIRHA method and hot air drying (70°C). These findings confirmed the effectiveness of SIRHA drying method to achieve simultaneous drying and decontamination of pistachios.

Key words: pistachio, infrared, SIRHA dryer, Pediococcus

Title: Drying and Decontamination of Pistachios by Sequential Infrared and Hot Air Drying

Authors: Chandrasekar Venkitasamy[1], Maria Brandl[2], Bini Wang[1, 3], Caiping Zhu[1, 4], Hamed El-Mashad, Tara H. McHugh, Zhongli Pan[1, 5]

Abstract:

Introduction: Sorting of dehulled pistachios in water results in significant moisture gain on the nut surface. Therefore, quick drying of pistachios is vital to avoid shell staining, decay and microbial contamination. The current hot air drying practices for pistachios have low drying rates, high labor and energy inputs, and do not guarantee safe products.

Purpose: The objectives of this research were to develop a sequential infrared and hot air (SIRHA) drying method for pistachios and evaluate its effectiveness to perform simultaneous drying and decontamination of pistachios.

Methods: Dehulled and sorted pistachios obtained from the Central Valley of California were dried in the SIRHA dryer using different combinations of time, and Infrared (IR) radiation and hot air drying to determine the optimum drying conditions. Pistachios were inoculated with *Pediococcus* and dried using the SIRHA dryer to evaluate the decontamination effect of the SIRHA drying method.

Results: The results showed that the SIRHA drying of pistachios (IR heating for 2 h at a product temperature of 70°C followed by hot air drying at 70°C) reduced the total drying time by 25.93% to lower the pistachios moisture content from 38.14% (w.b.) to 8.90% compared with hot air drying at 70°C alone. Drying of pistachios in the SIRHA dryer using IR heating at 70°C for 20 min, 1 h, and 2 h and holding the pistachios at 70°C for 1h followed by hot air drying to 8.90% MC resulted in *Pediococcus* population size reductions of 5.41, 5.60 and 6.39 log CFU/g, respectively, for pistachio kernels and 5.45, 5.42 and 5. 29 log CFU/g, respectively, for pistachio shells. No significant difference in peroxide value and free fatty acid contents was observed for the pistachios dried with the SIRHA method and hot air drying (70°C).

Significance: The results of this study confirmed the effectiveness of the SIRHA drying technology to achieve simultaneous drying and decontamination of pistachios.

Appendix 1 Figures and Photos

Figure 1. Locations of field sites at Orland, Waterford and Porterville, CA.

Figure 2. Study plot layout at field sites. C=control; L=low rate; M=medium rate; H=high rate.

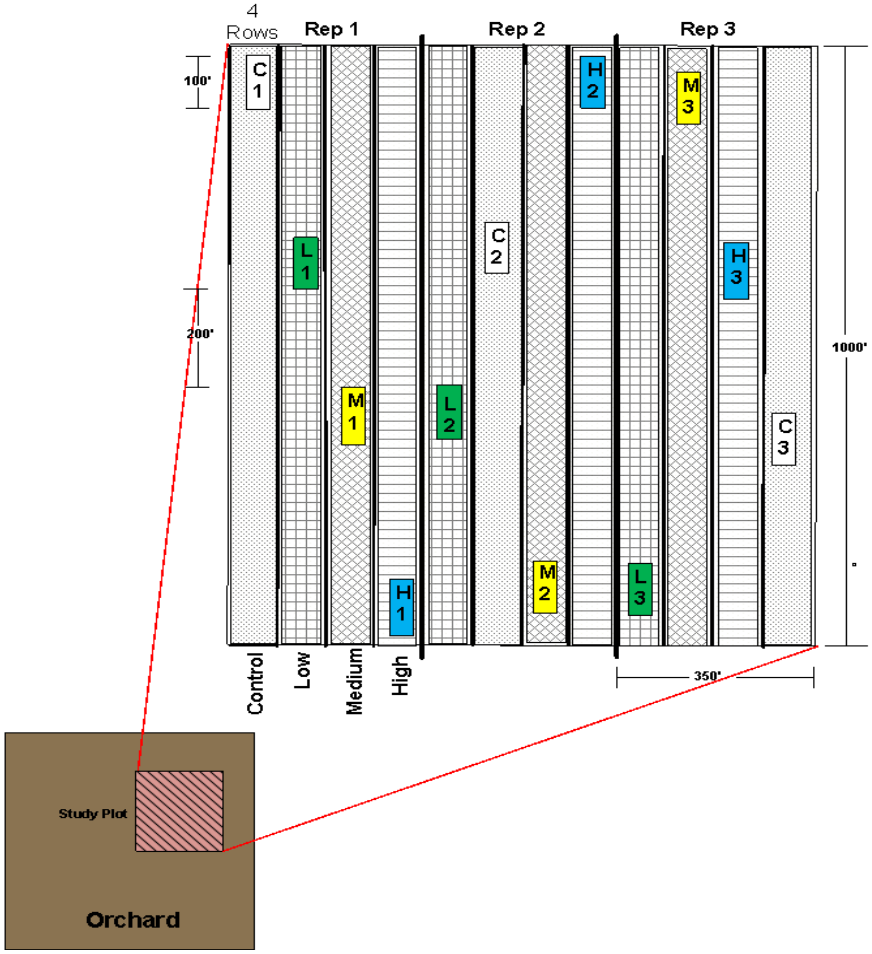


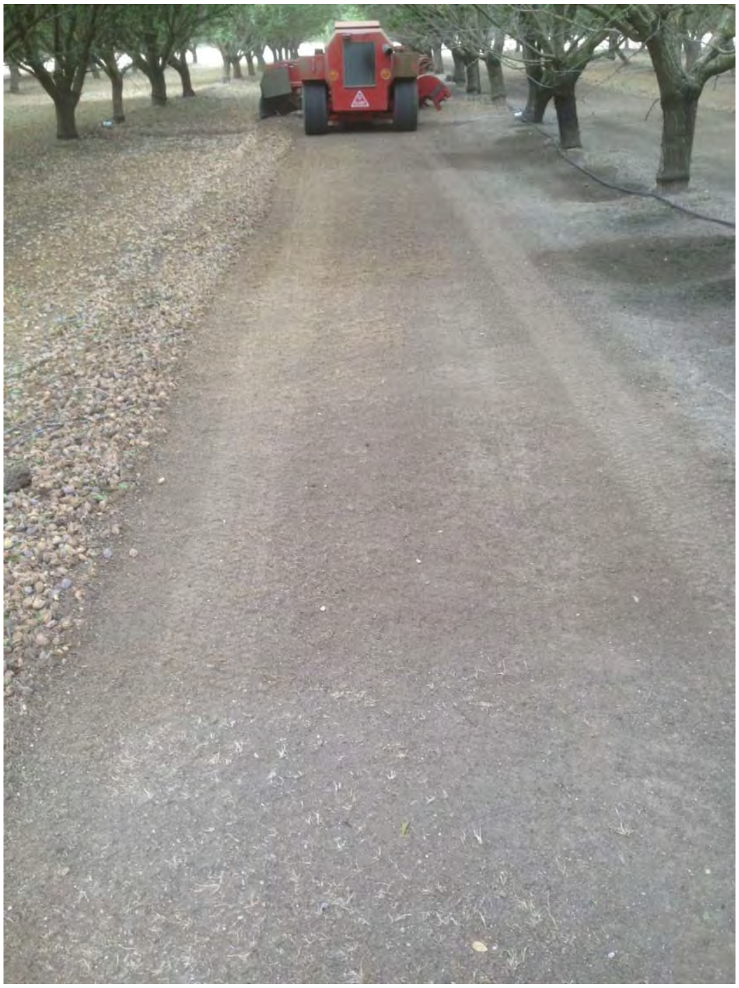
Figure 3. Application of Dust-Off with small scale agricultural sprayer.

Figure 4. Dust emission monitor (laser photometer) and data logger in ruggedized case (left) and mounted on ATV at field site (right).

Figure 5. Subplot after product application.

Figure 6. Deployed dust monitor during the shake process of the first year.

Figure 7. Residual product evident in a subplot after the sweep process has occurred.



Attachment 1 – SCB12038

Figure 1. Mean Annual Orchard GHG Emissions (using GWP_{100}). This graph depicts emissions for each crop on an annual basis, accounting for amortization of emissions associated with orchard establishment and end-of-life orchard removal, and accounting for typical orchard lifespans (25 yrs for almonds, 36 yrs for walnuts, 16 yrs for peach, and 31 yrs for plums). The standard Global Warming Potential (GWP_{100}) estimates the heat-trapping capacity of GHGs over a 100 year timeframe.

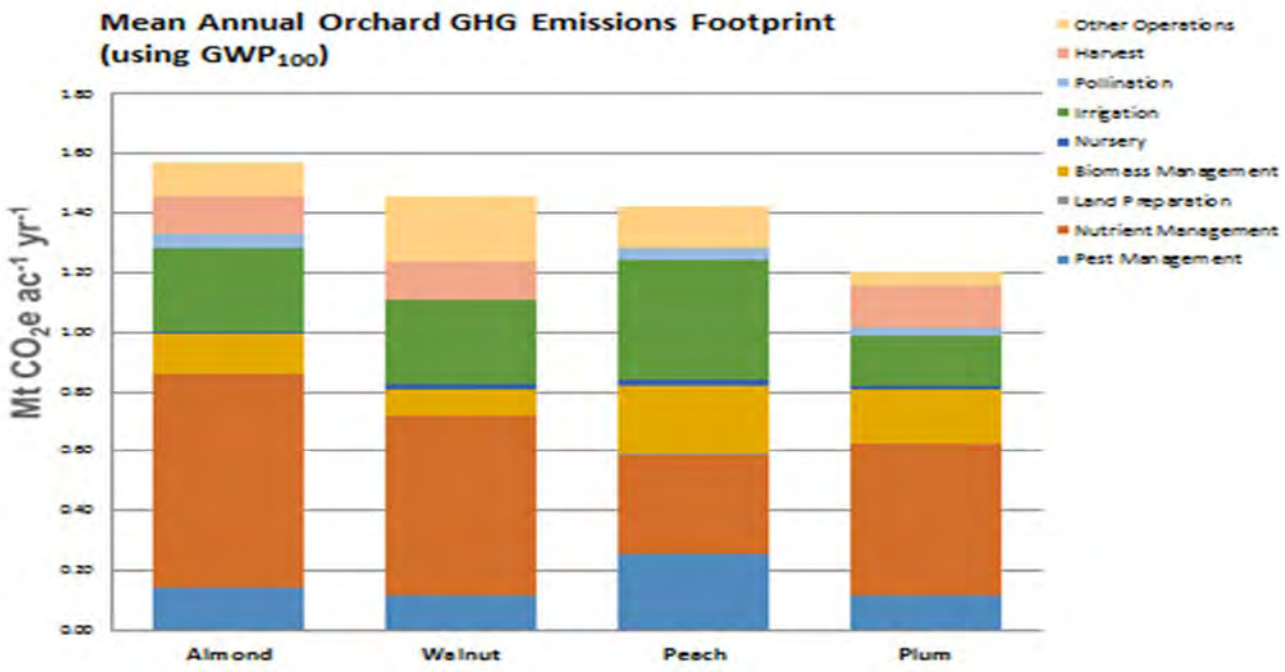


Figure 2. GHG Emissions and Credits (using $TAWP_{100}$)

This graph illustrates the magnitude of GHG emissions as well as credits due to long-term soil carbon storage, temporary biomass carbon storage during the orchard's lifespan, and displacement credits generated when co-products such as nut shells and end-of-life woody biomass are utilized by other industries in place of other materials or fossil fuels. Emissions and credits are expressed in CO_2-equivalents, calculated using a Time Adjusted Warming Potential (TAWP). TAWP is an alternative way of expressing GHG emissions, which accounts for when a GHG emission to or removal from the atmosphere occurs. The standard GWP approach typically sums all GHG emissions over the life cycle of a product, no matter when they occur, and any removals from the atmosphere over less than a 100-year timespan are not accounted for at all. Under this standard approach, the tree biomass in a 25-year-old orchard does not receive any credit as carbon storage, because the trees will be cut down and the carbon released to the atmosphere as CO_2 in less than 100 years. The TAWP, on the other hand, because it accounts for when an emission or removal occurs, can estimate the benefits of temporary storage of CO_2 in tree biomass, and calculates the equivalent amount of CO_2 today. This is analogous to estimating the net present value for monetary flows over time, answering the question of what the equivalent value is today for some future monetary flows. Using this approach, orchard trees that store carbon over a 25-year lifespan reduce the CO_2e of the orchard by temporarily removing CO_2 from the atmosphere.

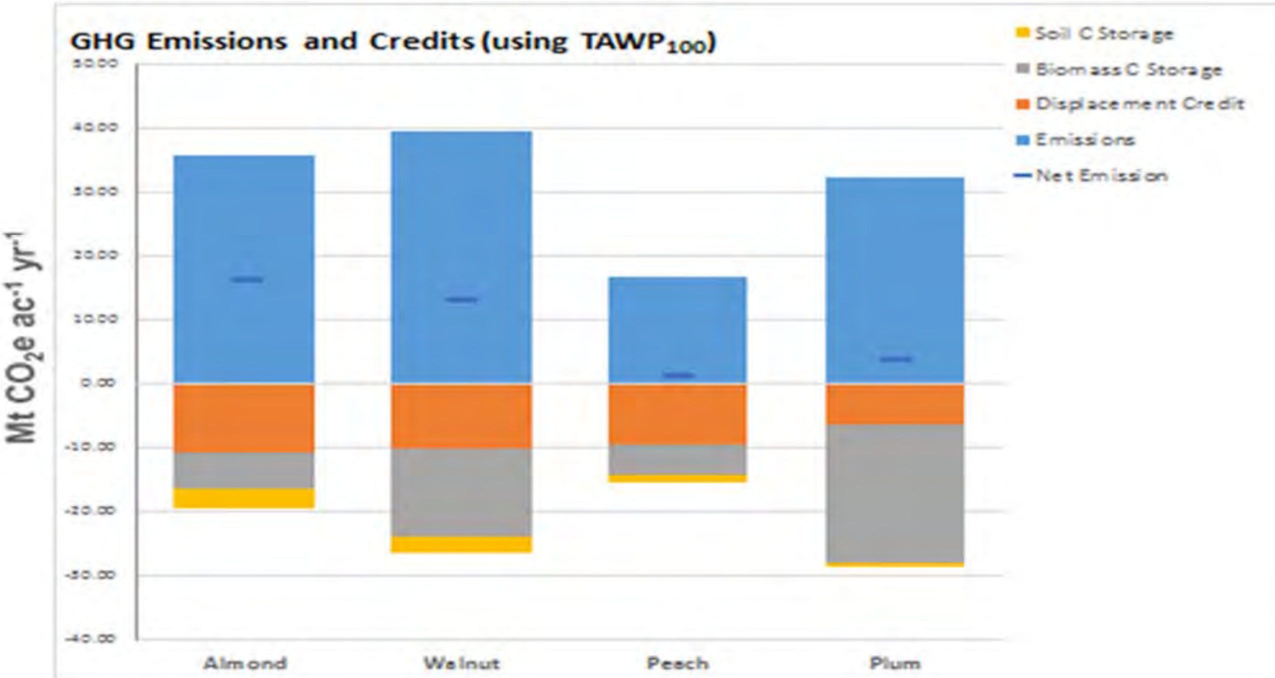


Figure 3. Mean Annual GHG Emissions from Nutrient Management in Organic Case Study vs. Conventional Walnut Production (using GWP_{100})

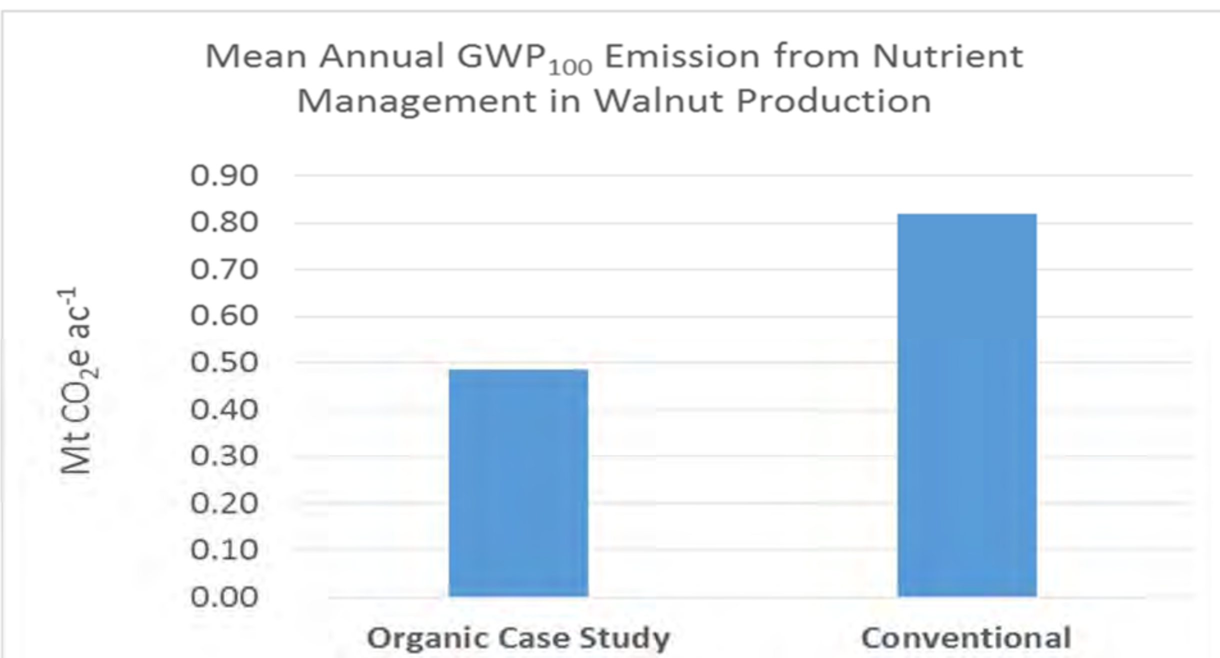
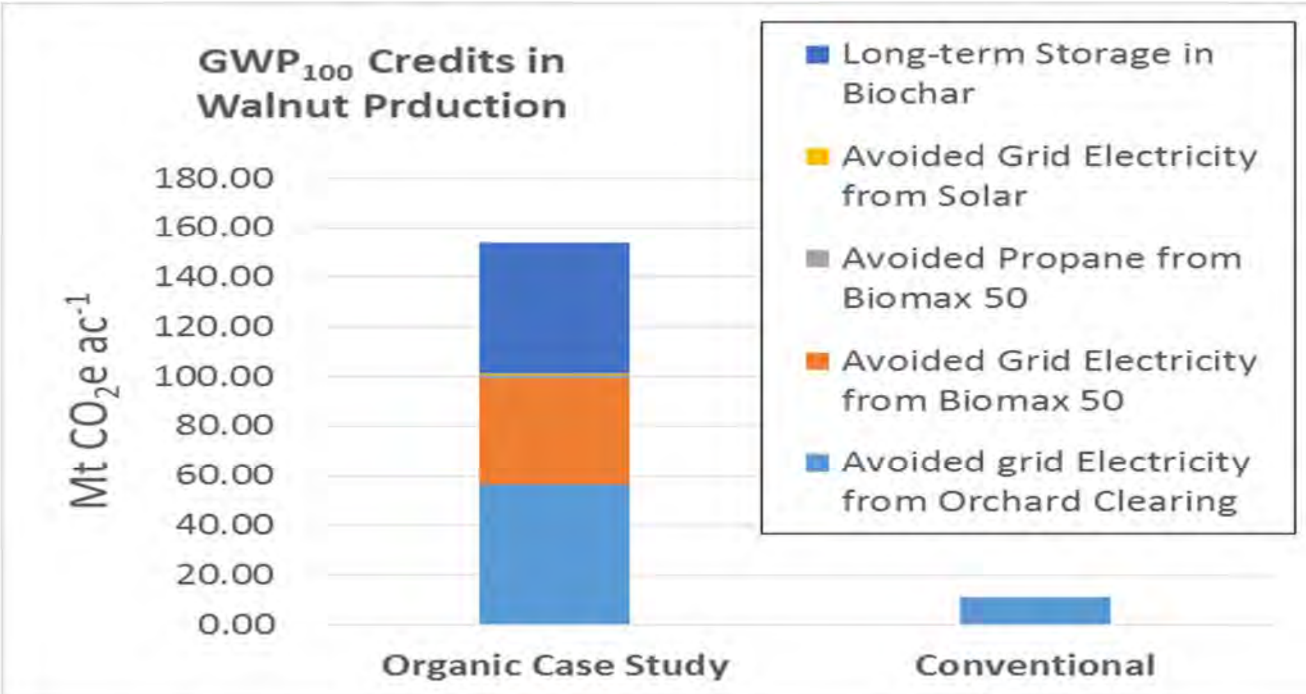


Figure 4. GHG Credits from Different Sources in Organic Case Study vs Conventional Walnut Production



Soil Emissions Field Work Results:

During the study period, N_2O equivalent to 925 and 702 kg of CO_2 per acre was released from the walnut and prune orchards, respectively (Table 1). In the walnut orchard, N_2O emissions

Table 1. Mean annual N_2O emissions (standard errors) in the organic walnut and conventional prune orchards. The annual emissions are also shown separately for the tree and tractor rows. The annual emissions are also shown in CO_2 equivalents (CO_2 eq.). Values designated by the same letters within the same column of each orchard are not significantly different ($P<0.05$). n = 3.

	Orchard		Trees		Tractor rows	
	kg N_2O-N/acre	kg CO_2 eq./acre	kg N_2O-N/acre	kg CO_2 eq./acre	kg N_2O-N/acre	kg CO_2 eq./acre
Walnuts						
Year 1	0.83 (±0.08)	388 (±37)	0.70 (±0.09)	132 (±17)	1.35 (±0.14)	265 (±27)
Year 2	1.15 (±0.19)	537 (±90)	0.73 (±0.10)	138 (±18)	2.10 (±0.47)	398 (±89)
Prunes						
Year 1	0.51 (±0.06)[a]	240 (±27)[a]	0.51 (±0.11)	96 (±21)	0.76 (±0.17)	144 (±32)
Year 2	0.98 (±0.03)[b]	462 (±14)[b]	1.53 (±0.02)	289 (±4)	0.91 (±0.10)	172 (±18)

were similar in the two years and by functional location, i.e. under the trees and in the tractor rows, although the emissions from the tractor rows tended to be larger (P=0.056), most likely because those areas received soil amendments, such as composted poultry manure. The orchard was irrigated most of time, even during the dormant period of the trees, and consequently, between 80 and 90 % of the total N_2O emissions were released during periods following irrigation events (Table 2). In the prune orchard, the N_2O emissions were significantly higher in the second year ($P<0.05$). The difference in emissions was probably due to the variation in synthetic N inputs. During the first year, 30 kg N per acre (65 lbs N per acre) were applied as urea ammonium nitrate in the irrigation water during early summer, whereas in the second year, 86 kg N per acre (190 lbs N per acre) were applied as ammonium sulfate before a heavy rainfall event in spring. The N fertilizer was applied under the trees in a relatively narrow strip (1.8 m wide). Nevertheless, the emissions did not differ by location (trees vs. tractor rows) overall, but the variation in N fertilizer application in the two years was evident in a significant year by location interaction ($P<0.05$). In the prune orchard, about 60% of the emissions occurred during or following rainfall events, mainly because the largest N fertilizer application was carried out during the rainy season.

Table 2. Mean total N_2O (standard errors) emitted from tree and tractor rows during the rainy and irrigation seasons in the walnut and prune orchards. The percentage emitted during the rainy and irrigation season from tree and tractor row locations is also shown.

	Walnut				Prunes			
	Trees		Tractor rows		Trees		Tractor rows	
	g N_2O-N / acre	%	g N_2O-N / acre	%	g N_2O-N / acre	%	g N_2O-N / acre	%
Rain	93 (±15)	16	150 (±36)	11	532 (±62)	63	397 (±94)	58
Irrigation	481 (±67)	84	1260 (±253)	89	310 (±15)	37	287 (±24)	42

Cultivar trait selection to improve tomato water use efficiency and yield under low water availability; Grant No. SCB12039

2. Materials and methods for the 2013 and 2014 field seasons

2.1. Field site

The experiment was conducted on a research station of the Harris Moran Clause Seed Company in Davis, California, USA (38°31'17.95"N, 121°41'28.42"W) during the 2013 and 2014 growing seasons. The soil series for the 2013 trial was mapped as 'Sycamore silt loam, drained', a fine-silty, mixed, nonacid, thermic Aeric Haplaquepts, whereas the 2014 trial was mapped as 'Reiff very fine sandy loam', a fine-silty, mixed, nonacid, thermic Typic Xerorthents (Soil Survey Staff, Natural Resources Conservation Service, 2011).

Historical average maximum and minimum temperatures (1983-2013) for the growing season (April-August) are 29.0 and 11.2°C, respectively, compared to 29.9 and 13.1°C in 2013, and 30.6 and 11.1ºC in 2014. Average precipitation is 5.11±2.95 cm (mean ± SE), but with the majority falling in April and May. Precipitation for the 5-month period was 1.6 cm in 2013, and 0.64 cm for 2014.

The experiments for both 2013 and 2014 had split-plot designs with two blocks. Each block consisted of six rows (2 data rows and 4 buffer rows). The irrigation treatments represented the main plots and were randomly assigned. In 2013, treatments were control vs. full season deficit irrigation comprising 20% of control. In 2014, treatments were control and terminal deficit irrigation comprising 20% of control for only the last half of the season. The subplots were randomly assigned within the main plots and consisted of the different genotypes.

2.2. Plant material

Several different sets of ILs were selected because they may possess specific traits that might improve production under deficit irrigation (see Eshed and Zamir 1994, 1995, Jones et al. 2007, and Gur et al. 2010 for more detailed information). The focus in both years was on processing tomato cultivar M82 and three ILs with an M82 background and genetic material from *S. pennellii* (IL2-1, IL5-4, and IL9-1).

Four other genotypes were only grown in 2013. They received less attention because published literature suggested they were less likely to perform well under deficit irrigation than the M82 group. These included the processing tomato E6203 (*S. lycopersicum* cv E6203) and its IL LA3965, with genetic material from *S. habrochaites*. The cold-tolerant *S. habrochaites* grows at high elevation (Easlon et al. 2013), and alpine plants are thought to be evolutionarily linked to desert species (Billings and Mooney 1968). Also, processing tomato cultivar Hunt100 (*S. lycopersicum* cv Hunt100) and its IL 'Sucrose' which contains genetic material from *S. chmielewskii* were included. This IL lacks an acid vacuolar invertase that converts sucrose into hexoses in the fruit (Yelle et al. 1991, Chetelat et al. 1995). As a result, the fruit of this IL accumulates high levels of sucrose which might result in better quality performance under drought conditions relative to Hunt 100.

Seeds for all ILs and background production cultivars were obtained from the C.M. Rick Tomato Genetics Resource Center (TGRC) at UC Davis (http://tgrc.ucdavis.edu). All seeds were surface sterilized and transported to the Westside Transplant LLC (www.westsidetransplant.com) where they were grown for six weeks before transplanting at the field sites.

2.3. 2013 Field season

Three families of ILs were evaluated in the 2013 field season, comparing two treatments: full irrigation control vs. extreme season-long deficit irrigation. A series of growth (i.e. morphological and developmental) and physiological measurements were collected throughout the growing season culminating with harvest. Some physiological data (primarily gas exchange measurements) were only collected on a subset of the genotypes, due to lack of instrumentation and time. This experiment was planted on an unexpectedly heterogeneous field (see below).

2.3.1. 2013: Field preparation and planting

Subsurface drip irrigation was installed at a depth of 25 cm prior to bed preparation. The field was comprised of beds 1.52 m across by 164.6 m in length. Fertilization management consisted of a pre-plant application of N-P-K (40 lbs of 8-24-6 acre^{-1}), an application of 5.7 L of 2-18-18 acre^{-1} during transplanting, and several weeks later a side dressing was applied (140 lbs of UN32 acre^{-1}). The overall pest and insect pressure on the field was low and was controlled with hand weeding and herbicides.

The experiment consisted of 12 adjacent beds: four data rows with a buffer row on each side of each data row. Due to limited seed for the ILs, the buffer rows and the first and last plots in each data row were planted with a standard production hybrid (cv. APT410). The transplants were planted into plots of 13 plants at 35.6 cm spacing between plants. Each plot was separated by a 91 cm unplanted section, and each row had 16 planted plots, each 4.63 m in length. The 8 genotypes were planted twice in each row. Transplanting occurred on April 9, 2013, after which plants received 2.54 cm of sprinkler irrigation. Due to high wind conditions in the two weeks after planting, an additional 2.54 cm was applied through the sprinklers. No additional water was supplied until the onset of the irrigation treatments.

Pre-planting gravimetric soil moisture in the bed tops was 0.194 ± 0.001, 0.198 ± 0.001, and 0.255 ±0.003 g H_2O g dry soil^{-1} (mean ± SE) for the 0-15, 15-40, and 40-75 cm depths, respectively. Irrigation treatments began on May 15, 2013 (37 Days after Planting (DAP)). For the control treatment, irrigation was applied to at the same time as adjacent Harris Moran Clause variety trials. The deficit irrigation treatment always received 20% of the run time as the control. Depending upon the ripening of each genotype in each irrigation treatment, 30 to 37 irrigation events were applied. Harvest dates were when 80% of the fruit was ripe, and varied according to each genotype x irrigation combination. Irrigation amounts ranged between 26.9 and 32.8 cm in the control plots and 9.4 and 10.6 cm in the deficit treatment plots. Variation in irrigation amounts within a treatment was due to variation in genotype harvest date. Irrigation amounts were calculated based on the flow rates and number of drip emitters per unit length of tape, and the duration of irrigation.

2.4. 2014 Field season

The M82 family of genotypes was chosen for the 2014 season, to better understand the wide range of morphological and physiological characteristics observed in the 2013 season. Two treatments were applied: full irrigation control vs. full irrigation through plant establishment and flowering, followed by a terminal deficit irrigation (20% of the control) starting at 50 DAP during fruit development.

2.4.1. 2014: Field preparation and planting

Seeds from the four M82 family genotypes (M82, IL2-1, IL5-4, and IL9-1) were prepared as described previously. Field preparation was the same as in 2013. The seedlings were transplanted at 6-weeks old into a different field at the same research facility (April 29, 2014).

Field pre-planting soil moisture contents in the bed tops was 0.117±0.023, 0.123 ± 0.031, and 0.154 ±0.039 g H_2O g dry soil^{-1} (mean ± SE), for the 0-15, 15-40, and 40-75 cm depths, respectively. More water was applied to the field this year as a result of a preceding drought and the sandier soil type. The deficit treatment was started 56 DAP. Total irrigation varied depending on genotype and irrigation treatment. For the control treatment, between 40.1 cm (M82 and IL2-1) and 46.5 cm (IL5-4 and IL9-1) was applied. For the deficit treatment, between 21.5 cm (M82 and IL2-1) and 22.8 cm (IL5-4 and IL9-1was applied.

Table 1: 2013 Field and lab measurements according to category of traits. DAP refers to days after planting.

2013 Trial

Description	abbreviation	DAP
Morphological and developmental traits		
Specific leaf area (cm^2/g)	SLA	50, 83
Canopy cover (%)	CC	23, 30, 63, 73, 91
Relative canopy cover from genotype maximum (%)	cover	23, 30, 63, 73
Specific leaf area lower canopy (cm^2/g)	SLAB	90
Specific leaf area upper canopy (cm^2/g)	SLAT	90

Leaf area index (m^2 m^{-2})	LAI	83
height (cm)	ht	83
Fruit set (%)	FS	59, 91
Number of flowers inflorescence^{-1}	Flwrs	38, 58, 91
Number of inflorescences	infl	38
Number of leaves on main stem	lvs	38
Physiological		
Leaf relative water content (%)	RWC	50, 83
Photosynthesis	photo	50,53 ,54, 55, 56, 57, 58, 59, 60, 63, 74, 78, 79, 80, 81, 83
Season mean photosynthesis	tmphoto	
Conductance	cond	50,53 ,54, 55, 56, 57, 58, 59, 60, 63, 74, 78, 79, 80, 81, 83
Season mean conductance	tmcond	
leaf $\delta^{13}C$	^{13}C	50, 83
Leaf % C	C	50, 83
Leaf %N	N	50, 83
Leaf C:N	CN	50, 83
SLA per g C	SLAC	50, 83
SLA per g N	SLAN	50, 83
Canopy NDVI	NDVI	23, 30, 63, 73, 91
Mean season NDVI	MNDVI	
Mean canopy temperature depression midseason	CTD1	56, 59, 63, 66, 69, 72
Mean canopy temperature depression late-season	CTD2	78, 91, 94, 99
Mean season canopy temperature depression	MCTD	
Photosynthetic nitrogen use efficiency	PNUE	83
Intrinsic water use efficiency	WUEi	83
Chlorophyll content (spad units)	SPAD	83
Upper canopy leaf N (%)	Tn	90
Upper canopy leaf C (%)	TC	90
Upper canopy specific leaf area by N	SLATN	90
Upper canopy specific leaf area by C	SLATC	90
Lower canopy leaf N (%)	BN	90
Lower canopy leaf C (%)	BC	90
Lower canopy specific leaf area	SLABN	90

by N		
Lower canopy specific leaf area by C	SLABC	90
Harvest		Include range of Harvest dates for the genotypes
Proportion of red fruit at harvest (%)	red	
Proportion of fruit with blossom end rot (%)	erot	
Proportion of rotten fruit (%)	rotten	
Proportion of sunburned fruit (%)	sunburn	
Fresh fruit biomass (g $fruit^{-1}$)	frshfrt	
Fruit dry matter content (%)	frtdmcor	
Dry fruit biomass (g $plant^{-1}$)	dfrtcor	
Fresh shoot biomass (kg)	frshshoot	
Dry fruit yield (kg)	Dyieldcor	
Fresh fruit yield (tons ha^{-1})	yield	
Brix yield (tons ha^{-1})	BY	
Harvest index	Hicor	
Fresh brix	Fbrix	
color (l)	color	
Crop water use efficiency (tons applied $water^{-1}$)	WUEc	
Fruit pH	ph	
Shoot (veg) dry matter content (%)	shootdm	
Dry shoot biomass (kg)	dshoot	
Shoot $\delta^{13}C$	$h\delta^{13}C$	
Shoot C (%)	hC	
Shoot $\delta^{15}N$	$h\delta^{15}N$	
Shoot N (%)	hN	
Shoot C:N	hcn	

Table 2: 2014 Field and lab measurements according to category of traits. DAP refers to days after planting.

2014 Trial

Description	abbreviation	DAP

Morphological and developmental traits		
Specific leaf area (cm^2/g)	SLA	71,86
Number of fruit	frt	74
Number of flowers inflorescence^{-1}	Flrinfl	74
Number of inflorescences	infl	74
Number of flowers	flwrs	74
Fruit set (%)	fs	74
Dry leaf mass (g)	lvs	74,85
Dry stem mass (g)	stms	74,85
Dry stem + leaf (g)	lsbio	74,85
Leaf to stem biomass ratio	Lsratio	74,85
dry fruit mass (g)	Frtm	74,85
Canopy cover (%)	CC	20, 38, 52, 69, 91
Relative canopy cover from genotype maximum (%)	cover	38, 52, 69
Physiological		
Leaf relative water content (%)	RWC	71,86
Sap flow rate ()	flow	74,85
Photosynthesis	photo	70, 71, 74, 75, 76, 77, 78
Season mean photosynthesis	tmphoto	
Conductance	cond	70, 71, 74, 75, 76, 77, 78
Season mean conductance	tmcond	
leaf $\delta^{13}C$	$\delta^{13}C$	71,86
Leaf % C	C	71,86
Leaf $\delta^{15}N$	$\delta^{15}N$	71,86
Leaf %N	N	71,86
Leaf C:N	CN	71,86
SLA per g C	SLAC	71,86
SLA per g N	SLAN	71,86
Root sap osmolality	Osmo	74,85
Canopy NDVI	NDVI	20, 38, 52, 69, 91
Mean season NDVI	MNDVI	
Canopy temperature depression	CTD	64, 69, 70, 71, 74, 75, 76, 77, 78, 85, 91, 94
Mean canopy temperature depression	MCTD	
Photosynthetic nitrogen use efficiency	PNUE	71
Mean Intrinsic water use efficiency	MWUEi	70, 71, 74, 75, 76, 77, 78

Harvest		Harvest date
Proportion of red fruit at harvest (%)	red	M82C/D 106/108
Proportion of fruit with blossom end rot (%)	erot	IL2-1C/D 106/108
Proportion of rotten fruit (%)	rotten	IL5-4C/D
Fresh fruit biomass (g $fruit^{-1}$)	frshfrt	IL9-1C/D
Fruit dry matter content (%)	frtdmcor	
Dry fruit biomass (g $plant^{-1}$)	dfrtcor	
Fresh shoot biomass (kg)	frshshoot	
Dry fruit yield (kg)	Dyieldcor	
yield (tons ha^{-1})	yield	
Yield of red and green fruit (tons ha^{-1})	RGyield	
Brix yield (tons ha^{-1})	BY	
Harvest index	Hicor	
Fresh brix	Fbrix	
Cooked brix	Cbrix	
color (a/b)	color	
bostwick (cm^{-1})	bostwick	
Titratable acidity	TA	
Fruit firmness	P5	
Crop water use efficiency (tons applied $water^{-1}$)	WUEc	
Fruit pH	ph	
Shoot dry matter content (%)	shootdm	
Dry shoot biomass (kg)	dshoot	
Shoot $\delta^{13}C$	h$\delta^{13}C$	
Shoot C (%)	hC	
Shoot $\delta^{15}N$	h$\delta^{15}N$	
Shoot N (%)	hN	
Shoot C:N	hcn	

2.5. Soil sampling

Soil was collected prior to transplanting for inorganic N, particle size, and gravimetric soil moisture. Two subsamples from each depth (0-15, 15-40, and 40-75 cm depth) were collected at different locations within a plot and bulked. Additional samples were taken at midseason (49 DAP) and at harvest (dates vary) during the 2013 season. For the 2014 season, there were 5 sampling dates corresponding to transplanting (8 DAP), just prior to the initiation of the deficit treatment (56 DAP), at each destructive sampling (74 and 85 DAP), and at harvest (dates vary according to ripening rate).

2.6. Harvest agronomic measurements

Plots were harvested when at least 80 percent of fruit was red. This varied by genotype and irrigation treatment, but each genotype within an irrigation treatment was harvested at the same time. Five plants per plot were clipped at the ground and all fruits were removed from the plants and sorted into marketable red (or yield), green, rotten, sunburned (2013 only), and fruit displaying symptoms of blossom end rot (BER). A subsample of the fruit was collected to obtain dry weights and individual fruit size. Shoots were weighed and a subsample removed for dry weight determination and tissue analysis. Fruit and shoot biomass were dried at 60°C. Harvest index was calculated as harvestable fruit divided by the total aboveground biomass at harvest on a dry weight basis. Crop water use efficiency (WUEc) was determined by dividing the yield by the applied water as determined by date of harvest.

Fruit quality was analyzed in 2013 (Brix, pH, and color) and 2014 (Brix, pH, color, titratable acidity, and Bostwick consistency) by the H.M Clause Seed Company using industry standards. Briefly, 10 to 20 fruit were blended using a food processor. pH was measured on the blended extract within 5 min of extract preparation using a bench top pH meter (Acumet AB150, Fisher Scientific, Pa. USA). Brix measurements were made on the same extract, after filtering to remove solids, and run on a refractometer (ATAGO RX5000, Atago USA, Wa.) at 22°C. Extracts of cooked tomato samples were degassed to completion (~5 min) using a vacuum pump. Color of the extract was measured on a Hunter colorimeter using the L-a-b scale (HunterLab, Va., USA). Titratable acidity was determined by adding 0.1N NaOH to 10 to 20 g of sample until the pH reached 8.0. Bostwick was measured on a Bostwick consistometer (CSC Scientific Company, Va., USA) over 30 sec. Brix yield (BY tons ha^{-1}) was determined by multiplying the Brix by the yield of marketable red tomatoes.

2.7. Growth (morphological and developmental) measurements

2.7.1. Growth measurements in 2013 and 2014

Canopy cover (an indicator of biomass) was measured using an infrared digital camera (ADC Lite; Tetracam Inc., California, USA) mounted on an inverted 'L'-shaped boom to capture an image directly above the bed. Images were taken at two-week intervals starting at 23 DAP in 2013 and 20 DAP in 2014. Images were processed using the Pixelwrench2 software (Tetracam Inc., v.1.0.9.3) to obtain the fraction of the surface covered by plant canopy and the NDVI. The relative percentage of the full canopy cover at a given day was used as an indicator of the plant physiological stage. This was calculated for four time points during canopy growth (23, 30, 63, 73 DAP for 2013 and 38, 52, and 69 DAP for 2014).

Specific leaf area (SLA) was measured twice on leaves that were used for photosynthesis measurements. Three terminal leaflets were collected from mature, fully expanded leaves from the top of the canopy. The leaflets were scanned and analyzed for area using ImageJ software (http:\\ImageJ.nih.gov/ij/). On 90 DAP in 2013, SLA was also collected on shaded leaves in the bottom third of the canopy as well as at the canopy top.

2.7.2. Growth measurements in 2013 only

Canopy height (from soil surface to topmost leaf) was measured on 83 DAP in 5 locations in each plot. Leaf area index (LAI) was determined using a solarimeter (AccuPAR-80, Decagon Devices, Inc. Washington, USA) on 83 DAP.

The total number of inflorescences, mean number of flowers per inflorescence, and the number of leaves on the main stem were counted on 38 DAP on one plant per plot. The total number of flowers and the number of fruit >1 cm diameter were counted on 58 and 91 DAP for 20 inflorescences per plot. As a measure of the timing of fruit set, the total number of fruit at each date was divided by the number of flowers on each date as measured across 20 inflorescences.

2.7.3. Growth measurements in 2014 only

Destructive biomass sampling occurred twice in 2014 at 74 and 85 DAP. At 74 DAP, the plants were collected and sorted into leaves, stems, and fruit and dried for tissue analysis and dry weight determination. Total numbers of open flowers, inflorescences with open flowers, and fruit were counted. The number of flowers inflorescence^{-1} was determined by dividing the number of flowers by the number of inflorescences. Fruit set at 74 DAP was determined by dividing the number of fruit by the total number of flowers. At 85 DAP, plants were again sorted into stems, leaves, and fruit as before, but flowers and fruit were not counted. For both time points, the ratio of leaves to stems was determined by dry weight.

2.8. Physiological measurements

Normalized difference vegetation indices (NDVI) were calculated for five dates in 2013 and 2014 using the canopy cover images as described above. The Pixelwrench2 software was used to determine the NDVI values for each image.

Canopy temperature depression (CTD) was measured using an infrared thermometer (Model VIR50, Extech Instruments, New Hampshire USA) as described in Pask et al. (2012). Measurements were conducted between 3 and 4 pm. CTD was calculated by subtracting the mean canopy temperature from the ambient air temperature (Pask et al. 2012). CTD measurements were made 10 times (2013) and 12 times (2014) over the season.

Leaf gas exchange measurements (photosynthesis (Pn), and stomatal conductance (gs) were taken 15 and eight times for the 2013 and 2014 seasons, respectively. Only three genotypes were measured in 2013 (M82, Il2-1, and IL5-4), while four were measured in 2014 (M82, IL2-1, IL5-4, and IL9-1). The terminal leaflet of an exposed mature, fully expanded leaf was measured using a portable open flow infrared gas analyzer (Li-6400; LiCor Inc, Nebraska, USA). Measurements were taken between 10:00 and 13:00 hours with the CO_2 reference set at 400 μmol m^{-2} s^{-1} and with saturating light using a LED source (PAR in: 2000 μmol m^{-2} s^{-1}). Intrinsic water use efficiency (WUEi) was determined by dividing the rate of photosynthesis by stomatal conductance (μmoles CO_2 $mole^{-1}$ H_2O m^{-2} s^{-1}). The leaflets used for gas exchange measurements were collected for additional measurements (see below).

Leaf relative water content (RWC) was determined as in Pask et al. (2012) at 50 and 83 DAP in 2013 and 71 DAP in 2014. In short, three sub-samples per plot of the terminal leaflet of a mature, fully expanded leaf were clipped and placed into a pre-weighed 50mL centrifuge tube with a moistened strip of filter paper (Whatman 1), sealed, and placed on ice to minimize water loss from the leaf. The tube was then re-weighed and tapped upon the counter repeatedly until the leaflet petiolules (the petiole of a leaflet) moved to the bottom, then five mL of DDI water were added to fully submerge the petiolules, and the tube was placed in a refrigerator overnight (18 hr). Leaflets were then removed from the tube and blotted dry to obtain a rehydrated weight. At this point, the leaflets were measured for surface area as described above. After scanning, the leaflets were dried at 60°C, weighed, and analyzed for C and N isotopes on a PDZ Europe ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire, UK) at the UC Davis Stable Isotope Facility (http://stableisotopefacility.ucdavis.edu).

Specific leaf area on an N (SLAN) and C (SLAC) mass basis were calculated from the results of the tissue analysis and the leaf area measured for SLA at 50 and 83 DAP. Samples from the top and bottom of the canopy were analyzed for both C (SLABC or SLATC) and N (SLABN or SLATN) at 90 DAP.

In 2013, measurements of leaf chlorophyll content (SPAD 502 Plus Cholorophyll meter, Spectrum Technologies, Inc., Illinois, USA) were conducted. This was on the same leaflet used for gas exchange measurements on 83 DAP.

In 2014 at 74 and 85 DAP, root sap was collected after the aboveground portion of the plant was harvested for biomass sampling. Briefly, after removing the shoots from one plant in each plot, the stump of the plant was washed with deionized water and blotted dry. Parafilm was then wrapped around the circumference of the stump and an appropriately sized 8 to 10 cm section of tygon tubing was placed over the stump and sealed using a zip tie. The sap was pipetted into a pre-weighed container when at least one mL of sap had collected in the tube, and depending on flow rates, from one to four tubes were collected from each plant. Tubes were placed into dry ice for transport back to the lab where they were placed in a -80°C freezer for later analysis. The sap flow rate was calculated by dividing the volume of sap by the collection time (<4 hrs).

The osmolality of the collected sap was measured with an osmometer from the second collection tube from each plot, to avoid any contamination from cells damaged during the cutting of the stem. Sap was also measured for ABA concentration from the first collection tube as some plots did not have more than 2 sample tubes, and ABA contamination was less of a concern due to the analytical procedure.

CENTRIFUGATION AS A PRE-TREATMENT IN OLIVE MILL WASTEWATER PROCESSING

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Introduction

Olive mill wastewater (OMWW), generated during production of olive oil, is an untapped source of nutritious compounds. Thus, processors want to separate OMWW into a high-value, concentrated product stream and near-pure water. However, the amount and characteristics of the produced OMWW depend on the milling system (2-phase or 3-phase). Since centrifugation is already used in the production of olive oil, it could be economically utilized as a pre-treatment in OMWW processing.

Objectives

The objectives of this study were to evaluate efficiency of centrifugation and identify optimum centrifugation time and speed for 2-phase and 3-phase OMWW using industrially-feasible conditions.

Experimental Design

2-phase and 3-phase OMWW from California mills

Laboratory centrifuge: different time and speed

Total solids (TS), dissolved solids (DS), and suspended solids (SS), turbidity, and chemical oxygen demand (COD)

A response surface design (Minitab); speed of 1500, 3500 and 5500 rpm, and times of 5, 32 and 59 min

Results

It was previously determined that the quality parameters of OMWW influenced by centrifugation are TS, DS, SS, turbidity, and COD. A response surface experiment (full factorial central composite design) was conducted to establish the speed/time combinations necessary to minimize values for all measured quality parameters in the separated near-pure water stream (Fig 1 and 2). The achieved removal efficiencies for the measured parameters were as shown in Fig 3.

Fig. 1 Contour plots for full factorial central composite design for 2-phase OMWW

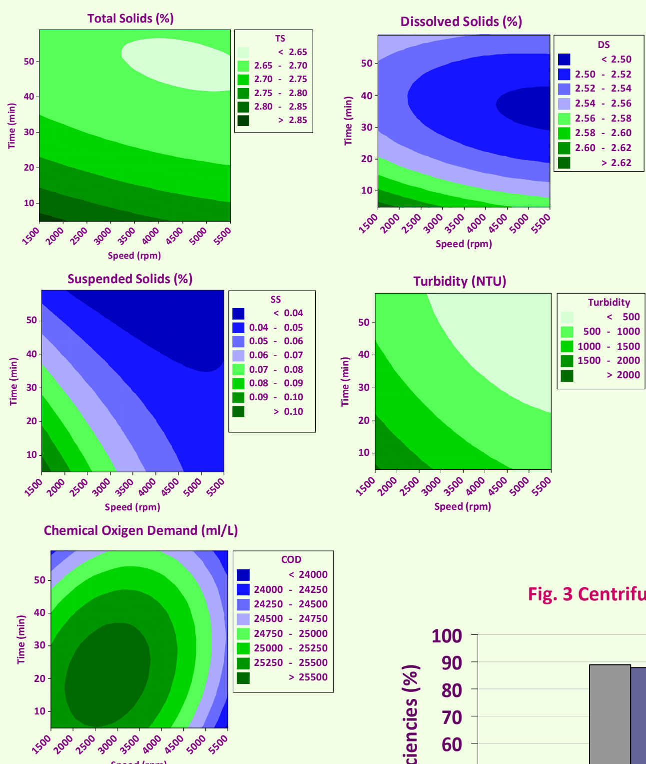


Fig. 2 Contour plots for full factorial central composite design for 3-phase OMWW

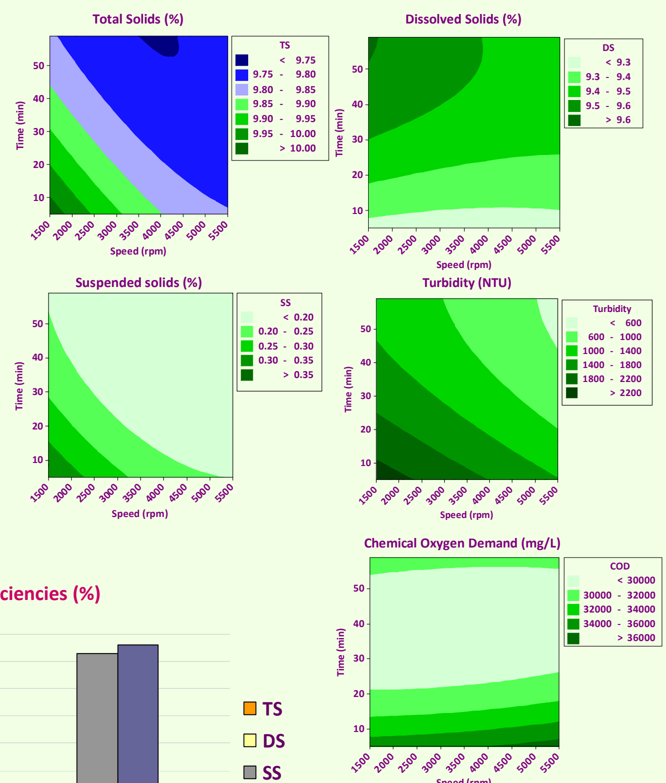
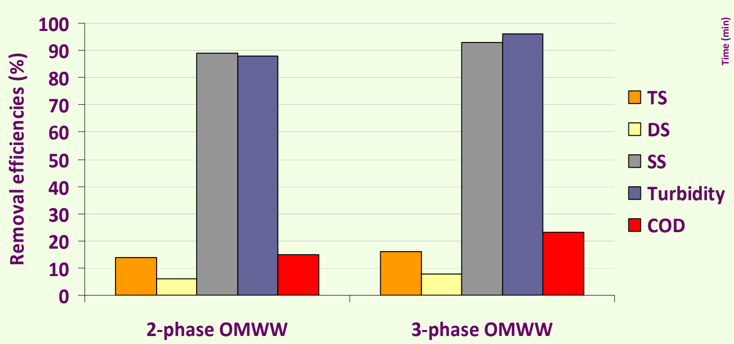


Fig. 3 Centrifuge removal efficiencies (%)



Conclusion

- Optimum removal efficiency for all tested parameters was achieved with centrifugation speed/time of 5,500 rpm (3,382 x g)/55 min for 2-phase OMWW, and 5,500 rpm (3,382 x g)/33 min for 3-phase OMWW.
- The removal efficiencies of the centrifugation process, especially in terms of SS, turbidity, and COD, indicate that centrifugation can be utilized in OMWW management. Initial centrifugation could improve the efficiency of subsequent separation processes, such as membrane filtration.
- The results of this study will help olive oil processors add value to their co-product OMWW stream.

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Membrane Filtration for Enrichment of Phenolic Compounds in Olive Mill Wastewater

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Introduction

Olive mill wastewater (OMWW), generated during production of olive oil, is an untapped source of health-promoting phenols. Processors are aiming to separate OMWW into a high value, concentrated co-product stream and near-pure water that can be recycled back into the milling process.

OMWW from three California mills (two 2-phase and one 3-phase) was collected and stored in a freezer for six months before treatment. OMWW was subjected to a sequential membrane filtration process using a novel vibratory system. Phenolic profile of the feed, permeate, and concentrate streams for each step in the process was analyzed by High Performance Liquid Chromatography (HPLC) with a Diode Array detector (DAD).

Objectives

- Develop an integrated filtration process that purify waste water, also isolate phenolic compounds;
- Identify and quantify phenolic compounds in waste water.

Samples

- The OMWW samples were provided by three California olive oil facilities;
- Two samples were from 2-phase process and one from 3-phase process;
- Initial feed, Permeate, and Final Concentrate were collected for analysis.

Table 1. OMWW Samples Origin

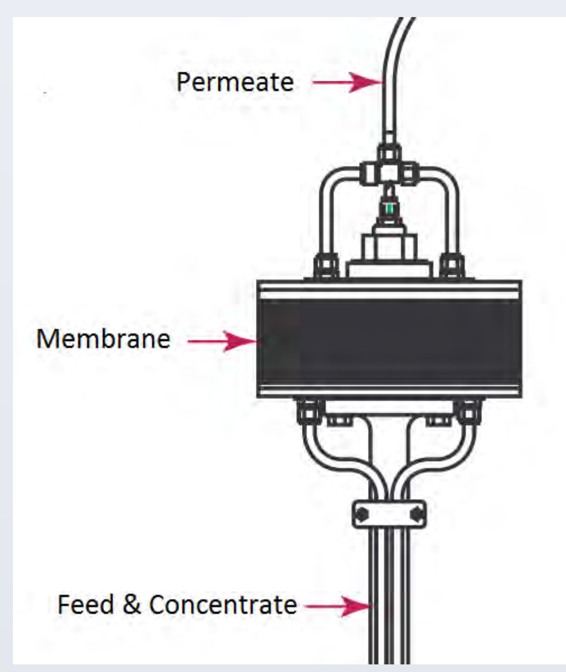
Sample Name	Abbreviation	Process Type
California Olive Ranch	COR	2-Phase
Seke Hill	SH	2-Phase
Il Fiorrello	IF	3-Phase

Methods

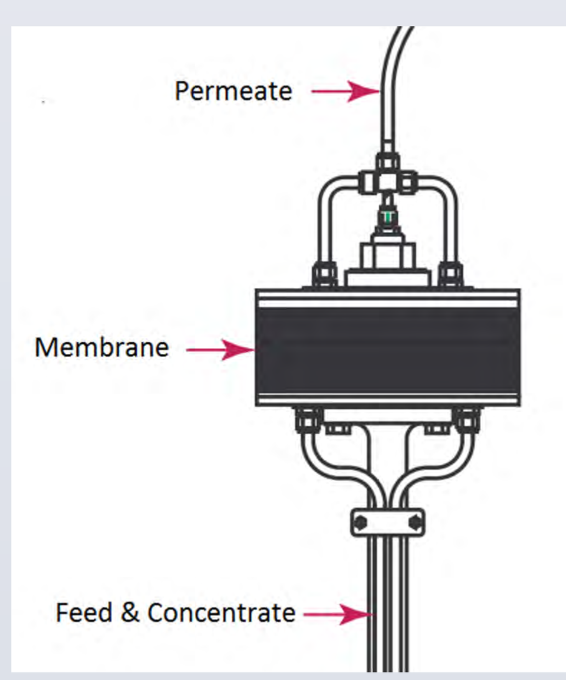
A two step sequential filtration process was developed with two membranes. Membrane selection completed with COR sample.

Table 2. Membrane Selection with COR Sample

Membrane	Type	Initial Flow*	Ending Flow*	Pressure	Conductivity	pH	%Solids	COD
0.05 um Teflon	MF	52	41	50 psi	4,300 µS	5.8	2.23 %	23,500 ppm
C-30F	UF	47	27	100 psi	4,010 µS	5.8	2.02 %	25,000 ppm
PES-5 / Tyvek	UF	28	28	100 psi	3,190 µS	5.9	1.26 %	13,000 ppm
ESPA	RO	29	25	300 psi	108 µS	5.9	0.00 %	960 ppm
				Feed:	5,350 µS	5.9	3.03 %	27,000 ppm



1st Step Filtration:
- Permeate collected for further filtration
- Concentrate is waste contains most solid waste



2nd Step Filtration:
- Feed is permeate from 1st step filtration
- Permeate is near pure water
- Concentrate is concentrated phrnol stream as product

HPLC condition:
- Reversed-phase C18 column (2.1*100mm, 2.7 µm)
- Injection Volume = 0.2 uL
- Flow Rate = 0.2 mL/min
- Wave Length = 280 nm

Table 3. HPLC Mobile Phase Gradient

Time/min	Solvent A/%	Solvent B/%
	0.1% Formic Acid	50/50 (v/v) Acetonitrile/ Methanol
0.00	100	0
30.00	70	30
40.00	50	50
42.00	90	10
45.00	100	0

Results

Fig.1 Membrane selection result, left to right: Initial Feed, 0.05 Teflon, C-30F, PES-5, ESPA

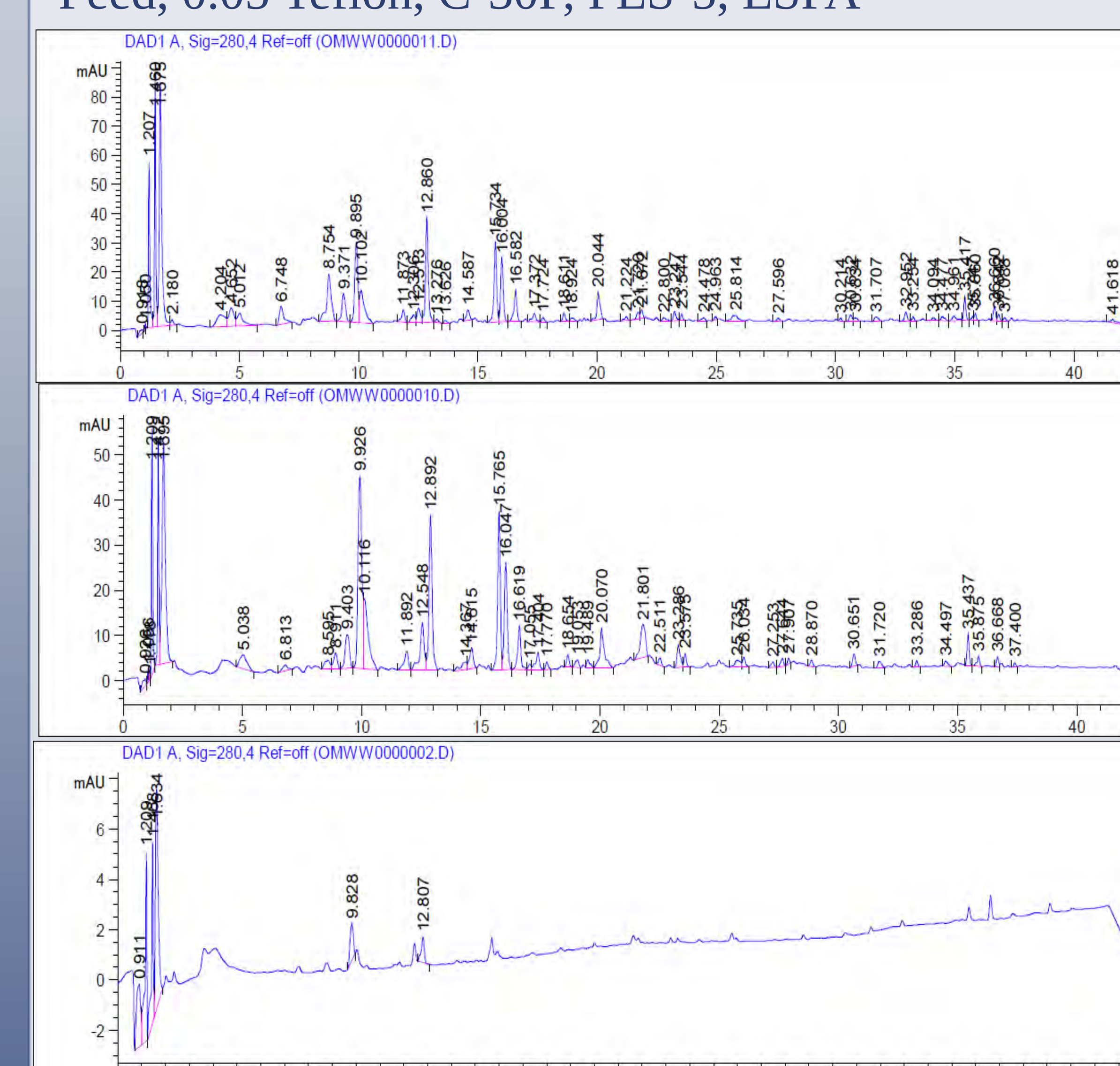


Fig.2 PES-5 permeate of COR, SH, IF Samples

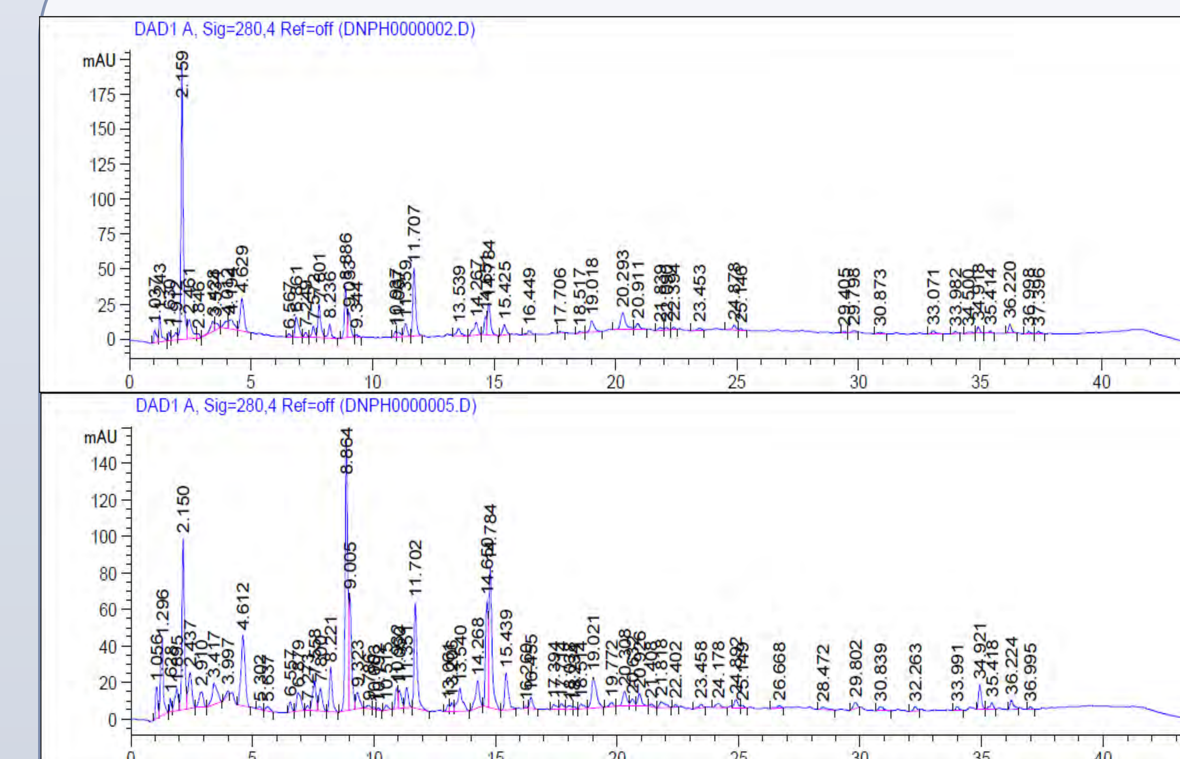


Fig.3 ESPA concentrate of COR, SH Samples

Conclusions

- Two-step sequential membranes filtration was developed with PES-5 and ESPA membranes.
- Over 85% recovery rate was reached at both steps.
- Filtration result was ideal since near pure water and concentrated phenol stream were produced for all samples.
- More phenolic compounds will be identified with external standards.

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OLIVE MILL WASTEWATER FILTRATION FRACTION: DRYING TECHNIQUES AND QUALITY ASSESSMENT OF THE DRIED PRODUCT

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[1]University of California, Davis, Davis, CA, USA, [2]USDA – Agricultural Research Service, Albany, CA, USA

Introduction

The California olive oil industry produces more than 600 million gallons of wastewater each year. Olive mill wastewater (OMWW) is considered a highly polluting effluent due to its high organic load and resistance to biological degradation. A current trend in OMWW management is to not only decrease environmental pollution but also extract and utilize valuable by-products.

Objectives

- to develop an energy-efficient separation technology for OMWW treatment
- to remove the highly toxic polluting effluent
- to extract health-promoting phenolic compounds

Experimental Design

Collection of 3-phase and 2-phase OMWW from California mills

→ Two-step membrane filtration process using a novel vibratory system

→ Characterization of membrane filtration fractions: UF retentate and permeate, RO retentate (RO-R) and permeate

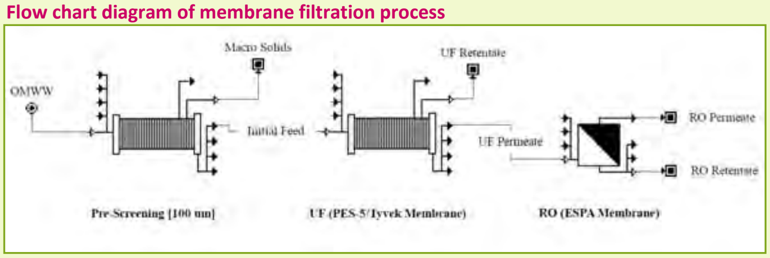
→ Spray-, freeze-, and infrared-drying of RO-R; physicochemical properties, total soluble phenolic content, and antioxidant activity of dried RO-R

Results

In this study, the OMWW was treated with a novel vibratory sequential membrane filtration system, including ultrafiltration (UF) and reverse osmosis (RO) filters. The phenolic rich fraction – RO retentate (RO-R) was dried using spray-, freeze-, and infrared-drying.

Flow chart diagram of membrane filtration process

Membrane filtration



Drying of reverse osmosis retentate (RO-R) + 10% Maltodextrin

Spray drying (SD)

Pilot plant scale spray dryer – the spray drying conditions: inlet temperature 130°C, exhaust temperature 65 °C, relative humidity 7.1-7.9 %, chamber pressure -1.66 mbar, cyclone differential pressure 5.8 mbar, feed pressure 0.21 bar, inlet fan (blower) 32 (Hz), exhaust fan (ventilator) 36 (Hz), feed pump 2.50 (Hz).

Freeze drying (FD)

Pilot scale freeze drier – frozen samples: programmed procedure: 72 h, included six drying steps (temperature from -20 °C to +20 °C, and vacuum from 500-200 mTorr).

Infrared drying (IRD)

Mathis Labcoater unit – samples were pipetted on Teflon sheets, placed on a Mylar sheet conveyor moving at 0.07 m/min. Infrared heater was adjusted to 70% and 0% infrared energy emission at top and bottom, respectively. The heating was set at 130 °C, fan speed was 2000 rpm, and dwell time was 10 min.

Process recovery, moisture content, and water activity of dried RO-R

Dried RO-R + 10%MD		Recovery (%)	Moisture (%)	Water activity
3-phase	SD	9.01 ± 0.62[a]	5.84 ± 0.47[b]	0.29 ± 0.01[c]
	FD	14.7 ± 0.88[b]	4.57 ± 0.76[a]	0.25 ± 0.00[b]
	IRD	14.3 ± 0.56[b]	5.24 ± 0.77[ab]	0.23 ± 0.01[a]
2-phase	SD	7.67 ± 0.22[a]	4.38 ± 0.75[b]	0.17 ± 0.01[b]
	FD	9.37 ± 0.09[c]	2.00 ± 0.04[a]	0.08 ± 0.00[a]
	IRD	8.49 ± 1.32[b]	4.60 ± 0.26[b]	0.18 ± 0.04[b]

Values are means of three determinations ± standard deviation. Values in each column with the same superscript are not significantly different ($P < 0.05$).

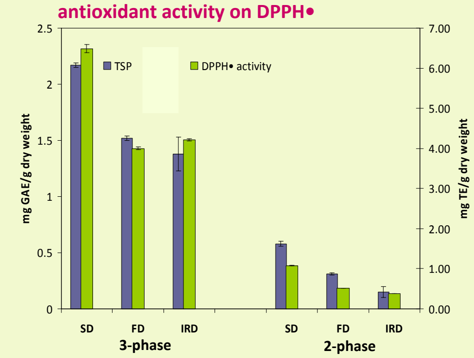
Dried 3- and 2-phase RO-R

Concentration of phenolic compounds in dried RO-R (µg/g dry weight)

Dried RO-R		3-Hydroxytyrosol (280 nm)	Tyrosol (280 nm)	Vanillic acid (254 nm)	*p*-Coumaric acid (320 nm)
3-phase	SD	108.1 ± 13.3	138.7 ± 23.6	105.3 ± 6.1	24.5 ± 5.1
	FD	35.2 ± 3.9	62.8 ± 7.6	33.5 ± 11.7	9.3 ± 1.2
	IRD	26.5 ± 1.5	44.9 ± 2.5	20.9 ± 4.3	6.7 ± 0.7
2-phase	SD	n.d.	71.3 ± 3.0	23.2 ± 1.6	8.0 ± 0.1
	FD	n.d.	32.8 ± 4.7	7.4 ± 1.7	5.4 ± 1.0
	IRD	n.d.	4.5 ± 0.5	2.8 ± 0.4	1.1 ± 0.2

Values are means of three determinations ± standard deviation.

Total phenolic content of dried RO-R and antioxidant activity on DPPH•



Conclusion

- Findings from this study confirm that the two-step sequential membrane filtration process using novel vibratory system can be successfully utilized in OMWW treatment.
- The obtained RO retentate is a phenolic-rich filtration fraction, and the RO permeate is a near-pure water that could be recycled into the milling process.
- Drying of the RO-R stream, especially by spray drying, results in a powder that contains phenolics.
- Further characterization of the dried material is needed for its possible applications in nutraceutical, feed or food industries.
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SUSTAINABLE TECHNOLOGIES FOR OLIVE MILL WASTEWATER MANAGEMENT

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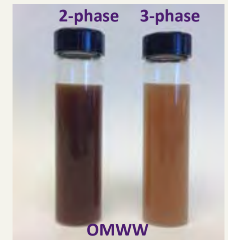

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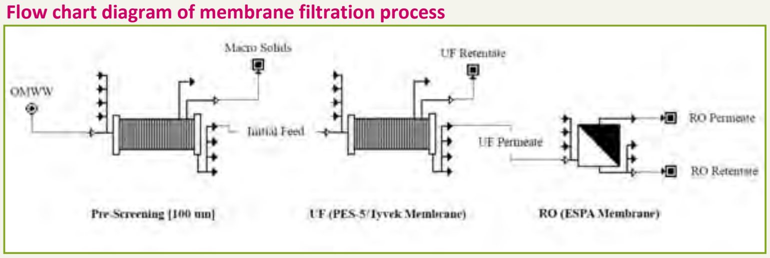

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Physicochemical properties of the initial feed and fractions produced by UF and RO filtration of OMWW

3-phase OMWW	Total Solids (%)	Dissolved Solids (%)	Suspended Solids (%)	Turbidity (NTU)	COD (g/L)	pH	Conductivity (mS)
Initial feed	3.73 ± 0.02^{b}	2.99 ± 0.05^{c}	3.01 ± 0.08^{b}	13983 ± 60^{b}	50.5 ± 0.17^{b}	5.46 ± 0.01^{c}	4.54 ± 0.05^{c}
UF retentate	12.8 ± 0.06^{d}	6.60 ± 0.24^{e}	8.27 ± 0.19^{c}	46633 ± 756^{c}	220 ± 0.16^{d}	5.04 ± 0.08^{a}	11.4 ± 0.04^{d}
UF permeate	0.66 ± 0.04^{a}	0.69 ± 0.02^{b}	n.d.	3.43 ± 0.03^{a}	8.99 ± 0.05^{a}	5.22 ± 0.02^{b}	2.46 ± 0.02^{b}
RO retentate	$\mathbf{5.39 \pm 0.04^{c}}$	$\mathbf{5.68 \pm 0.03^{d}}$	$\mathbf{0.02 \pm 0.00^{a}}$	$\mathbf{28.4 \pm 2.5^{a}}$	$\mathbf{68.1 \pm 0.16^{c}}$	$\mathbf{4.99 \pm 0.03^{a}}$	$\mathbf{16.3 \pm 0.17^{e}}$
RO permeate	**n.d.**	$\mathbf{0.01 \pm 0.00^{a}}$	**n.d.**	$\mathbf{0.32 \pm 0.06^{a}}$	$\mathbf{0.81 \pm 0.00^{a}}$	$\mathbf{5.59 \pm 0.03^{d}}$	$\mathbf{0.08 \pm 0.00^{a}}$
2-phase OMWW							
Initial feed	0.35 ± 0.02^{b}	0.29 ± 0.01^{b}	0.08 ± 0.00^{a}	1014.3 ± 7.5^{b}	5.45 ± 0.11^{c}	7.15 ± 0.03^{d}	0.87 ± 0.00^{b}
UF retentate	1.59 ± 0.09^{d}	0.72 ± 0.00^{c}	0.94 ± 0.08^{b}	11416 ± 20.8^{c}	27.4 ± 0.41^{e}	6.70 ± 0.01^{c}	2.54 ± 0.02^{d}
UF permeate	0.16 ± 0.03^{a}	0.16 ± 0.01^{a}	n.d.	5.80 ± 1.00^{a}	1.59 ± 0.04^{b}	6.75 ± 0.03^{c}	0.47 ± 0.00^{a}
RO retentate	$\mathbf{0.86 \pm 0.01^{c}}$	$\mathbf{0.84 \pm 0.00^{d}}$	**n.d.**	$\mathbf{9.03 \pm 0.2^{a}}$	$\mathbf{9.87 \pm 0.67^{d}}$	$\mathbf{6.46 \pm 0.01^{b}}$	$\mathbf{2.36 \pm 0.03^{c}}$
RO permeate	**n.d.**	**n.d.**	$\mathbf{0.48 \pm 0.17^{a}}$	$\mathbf{0.48 \pm 0.17^{a}}$	$\mathbf{0.16 \pm 0.02^{a}}$	$\mathbf{5.27 \pm 0.06^{a}}$	**n.d.**

Values are means of three determinations ± standard deviation. Values in each column with the same superscript are not significantly different ($P < 0.05$). n.d. – not detected.

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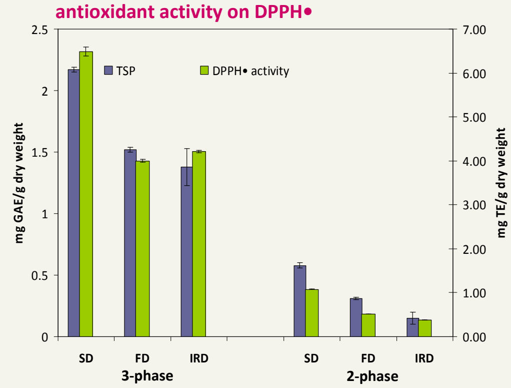

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Olive Milling Wastewater Reuse:

A Look at Potential Costs and Benefits of Filtration and Drying in California

A Report for the UC Davis Olive Center

DRAFT

October 2015

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UC Davis

California Olive Milling Wastewater Reuse:

A Look at Potential Costs and Benefits of Filtration and Drying in California

1. Introduction

The handling of olive milling wastewater (OMWW) is becoming an increasingly important issue to California millers, as evidence mounts that historically-used disposal methods (including discharge to waterways and applications to fields) can cause significant environmental problems. While virtually all of the OMWW stream consists of organic material that, at the right levels, can be quite beneficial to people and animals, the phenolic content in the raw OMWW stream is typically too concentrated for direct applications. As a result, the otherwise-beneficial antimicrobial, antibiotic, and antioxidant properties of OMWW become toxic, interfering with normal soil functions and creating groundwater and surface water pollution problems worse than those resulting from dumping equivalent volumes of raw sewage into the water bodies.

In addition, California and other states monitor water discharges carefully under both state and Federal Clean Water Acts, which generally prohibit unregulated water discharges. Thus, environmentally-compliant millers have relatively few good options for handling their OMWW. Adopting a 2-phase milling process (which separates olives into oil and water-solids streams) as a replacement for 3-phase milling (which separates olives into oil, water, and solids streams) reduces overall volume of water is used in the milling process, but doesn't solve the basic problem of disposal.

A viable, but expensive, disposal option is to have the OMWW trucked away which is a common practice currently. In addition to its direct costs, with recent improvements in understanding the chemical composition of OMWW and the potentially-valuable ingredients it contains, paying to have OMWW trucked away is more costly to millers than the transportation cost alone would indicate, since potential additional revenue streams from olive milling are also lost.

Research on alternative OMWW disposal methods has been underway in Europe for at least a couple of decades, and in California for a much shorter period of time, but as yet no completely satisfactory industrial-scale solutions have been found. Recently, work both in Europe and at UC Davis has focused on the use of filtration systems, identifying the mass flows and constituents of the materials separated from ("retentates") and passing through ("permeates") each filtering process.[1] In the European case, though the data are not extensive, there are indications of high market value for some of the products from OMWW filtration.

The purpose of this paper is to examine the prospective costs and benefits of filtration systems for OMWW in California, drawing on a variety of information both from the published literature and from industry sources.[2] First, the major operating and equipment capital costs associated with a particular industry-scale (24,000 gal/day) OMWW ultrafiltration (UF) and reverse osmosis (RO) filtration systems are assessed, with and without drying the retentate from RO. (This is done because there are indications of potential economic value for the retentate both in wet and dried forms.) Then the major potential economic benefits of OMWW filtration and reuse are discussed.

[1] The principal filtering processes evaluated both in California and in Europe are ultrafiltration and reverse osmosis. European investigators have also looked at nanofiltration. More details on these can be found in, for example, Arvaniti *et al*. (2012) for European research, and Sedej *et al*. (2015a,b) for California.
[2] This is necessary because there do not appear to be any actual markets for OMWW products either in Europe or in California, and since research into treatment methods is still very new, there is little or no hard evidence (in the form of market prices or industry scale production costs) to draw upon.

The potential economic benefits fall into two categories: the relatively easily identified and valued benefits (disposal costs avoided and near-pure water produced, for either reuse in the milling process or for other purposes), and those that are inherently more speculative due to the paucity of information available (wet UF retentate, and wet or dried RO retentate). In each of these latter cases, there is some value information that is highly suggestive, but it may be for a different product derived from the retentates that requires further refining or production; or there may be additional handling, storage, or transportation costs that are difficult to assess in a meaningful way, since they likely will vary with the particulars of each mill and region.

Caveats

It is important to note that this analysis is inherently somewhat speculative, given the absence of data based on actual experience with industry-scale OMWW filtration and market development for the resulting products in California and the USA as a whole. Inevitably, not all the costs (notably the costs of providing space for the filtration equipment) of operating the OMWW filtration system are included, as these will vary widely depending on the particular configurations and constraints of each mill. In addition, as noted above, much of the value information is prospective and not necessarily well-matched to the cost data. <u>Thus, the analysis must be viewed as suggestive rather than definitive.</u>

Nevertheless, the information that has been assembled from widely disparate sources does suggest optimism regarding the economic benefits from OMWW filtration in California. Encouragingly, the relatively ‘hard’ economic benefits (disposal costs avoided and water values) appear to exceed the equipment acquisition and operation costs for production of wet retentates from the OMWW stream, without even considering the ‘soft’ economic benefits from the UF and RO retentates. The ‘hard’ economic benefits are less than the costs of producing dried retentates, but this is an optional production decision that presumably would be made only when the resulting (incremental) benefits of drying the retentate exceeded the marginal costs of drying the retentates.

When the (speculative, at this point) potential values of the products that result from filtering are brought into consideration, they suggest a potentially large economic upside, though this may be some time off as it is necessary for markets and market channels to develop for the wet filtration outputs, as apparently they are in Europe.

The paper is organized as follows. The following section (Section 2) evaluates the relatively ‘hard’ benefits of OMWW filtration in a cost-effectiveness analysis, <u>without</u> considering the prospective benefits of the products which can be derived from the OMWW stream. The question in this section is one of cost-effectiveness: is OMWW filtration a less expensive treatment option (relative to trucking wastes away for disposal) for OMWW, for an environmentally compliant firm? Environmental compliance effectively rules out disposing of OMWW on agricultural lands or in waterways, because concentrations of phenolics are too high and environmentally damaging, leaving paying for disposal at a third-party site as the default disposal option.

Sections 3-7 take up the question of what the ‘soft’ benefits of OMWW might be, considering the various products which can be recovered from the OMWW stream and their prospective values, once markets for those products develop (which seems likely given the apparent high value of the OMWW stream constituents and the expansion of olive oil industry). Section 3 develops an industry-scale mass balance for the constituents of OMWW, based on both the volume of a fairly standard mid-large scale filtration system and detailed UC Davis Olive Center lab-scale test results on the makeup of the OMWW stream. Section 4 presents market information about the retail values of the constituents identified in the OMWW retentates. Section 5 develops a simple approach to assess the prospective revenues at wholesale of wet retentates from both UF and RO, which is one major option with OMWW filtration. This analysis is based on some limited and hard to verify (at present) market information in Europe from the scientific literature, with adjustments for the phenol concentrations in the California OMWW samples relative to those reported in Europe. Section 6 evaluates the prospective wholesale values of dried retentates from both UF and RO filtration, based on information about likely USA prices for some types of hydroxytyrosol-standardized[3] products. Section 7 discusses the other main product of OMWW filtering, near-pure drinking water (with no detectable traces of phenolics in the samples), and its potential value in stretching milling water supplies.[4] Section 8 concludes.

2. Cost-effectiveness of OMWW filtration

This section considers the costs of OMWW filtration, with and without drying of the retentates from ultrafiltration and reverse osmosis. To be conservative in an assessment of the potential economic viability of the method, this analysis considers simply the relative costs of OMWW filtration versus the main environmentally-compliant alternative, trucking OMWW to third-party sites for disposal. The benefits of OMWW filtration considered here are the cost

[3] Hydroxytryrosol (also known as 3-hydroxytryrosol, among other names), seems to be the most potentially-valuable phenolicsin the OMWW stream (where it appears), and a number of substances used in pharmaceuticals manufacturing and chemical testing are based on this ingredient as a standard.
[4] Given current drought conditions in California, this aspect of OMWW filtration is appealing.

savings compared to trucking disposal, and the value of water produced by filtration, for which there are relatively well-characterized market values.

To begin the analysis, a brief description of basic OMWW filtration processes may be helpful. The waste water from milling consists of a "non-food grade" stream from initial washing and debris removal, and a "pre-screened" food grade stream which consists entirely of natural products (Arviniti *et al.* 2012) that can be concentrated and dehydrated through filtering processes. The pre-screened OMWW is first pressed through an ultra-filtration system, which results in two products – a "retentate" (UF-R) that doesn't pass through the UF, and a "permeate" that does pass through. The UF permeate is then pressed through a reverse osmosis filter, which in turn produces a retentate (RO-R) and a RO permeate, which is near-pure water. Thus, UF and RO applied to the pre-screened OMWW stream results in 3 products: UF-R, RO-R, and near-pure water. Each of these may have economic value; as noted above, these values are taken up after the cost-effectiveness analysis of this section.

The cost-effectiveness analysis considers the capital and operating costs of a 24,000 gal/day OMWW filtration system, which appears to represent the needs of a medium to large olive milling operation. How large a milling operation would generate this volume of OMWW depends on the type of milling: European evidence, predominantly with 3-phase milling, is that 1-1.6 metric tons (mt) of OMWW is generated per mt of olives milled for 3-phase mills, and a much smaller ratio (0.2 mt OMWW/mt of olives milled) with 2-phase milling (Santori). In contrast, industry sources suggest that the ratio for California 2-phase milling is about 0.5 mt OMWW/mt of olives milled (Bolton). Given that the densities of OMWW and pure water are comparable (Milczarek), this range of estimates suggests that the 24,000 gal/day (which is, equivalently, about 45.4 mt/day) filtration system could be adequate for a 2-phase plant milling 90-225 mt of raw olives per day, and for a 3-phase plant milling 28-45 mt per day.

New Logic, the maker of the filtration system used in this study, shared the major capital and operating expenses for the system, given in Table 1.

Table 1. Fixed costs for a 24,000 gal/day OMWW filtration system[a]

Item	Wet RO Retentate	Dry RO Retentate
Filters		
Pre-screen filter system	$20,000.00	$20,000.00
UF filter system	$280,000.00	$280,000.00
RO filter system	$96,000.00	$96,000.00
Other Materials		
Process Tanks	$60,000.00	$60,000.00
Power Distribution and connection	$45,000.00	$45,000.00
Platform and Hoist	$15,000.00	$15,000.00
Labor -- Installation (200 hrs)	$10,500.00	$10,500.00
Drying Equipment[c]		$160,000.00
Total fixed costs	$526,500.00	$686,500.00

[a] Source for all costs except drying equipment and labor is New Logic
[b] Reverse Osmosis retentate
[c] Super-Pro simulation estimates

The first data column of Table 1 has the fixed costs for producing wet retentates from UF and RO, while the second data column is for drying the wet retentates into a dried powder form. The only difference in costs between the two filtration systems is the added cost for a spray drying unit, which SuperPro simulation software estimates at approximately $160,000.[5] The principal

[5] All other costs listed in Table 1 are from New Logic, except for the labor estimates, which added by the author to be somewhat conservative in estimating costs.

capital costs are, not surprisingly, those for the UF and RO filtration systems themselves – they comprise nearly $380,000 of the total $527,000 of capital costs for producing wet retentates.

The principal operating costs for producing wet and dry retentates are given in Table 2. As with capital costs, the dried retentate operation has the same filtration-related costs as for wet retentates, with some additional costs associated with spray drying. The largest single filtration cost is replacement of membranes, with an amortized daily cost of about $83; this is about 44% of the daily wet retentate operating cost of about $189/day.[6]

Table 2. Operating costs for a 24,000 gal/day OMWW filtration system

Item	Wet RO Retentate	Dry RO Retentate
Filtration		
Power (213.6 kwH/day, $0.10/kwH)[a]	$21.36	$21.36
Membrane Replacement Cost[b]	$82.56	$82.56
Cleaning Chemicals [a]	$32.16	$32.16
Labor (incl. 50% overhead) [c]	$52.50	$52.50
Spray Drying		
Maltodextrin [c] (1805 lb/day, $0.40/lb)		$722.00
Labor (incl. 50% overhead)		$813.75
Power (steam/electric)		$196.24
Cost/day	$188.58	$1,920.57

[a] *Source*: New Logic for filtration costs; SuperPro for spray drying
[b] Amortized daily cost
[c] Labor rate based on a wage of $35/hour; with overhead and benefits, the daily labor rate is $52.50/hr.
[d] Combined maltodextrin and power costs vary slightly for 2-phase vs. 3-phase plants. The costs listed here are for a 2-phase plant; the combined costs for a 3-phase plant are approximately $11/day higher.

The operating costs for filtration and spray-drying are about an order of magnitude higher than those for filtration only, and are dominated by maltodextrin (a drying accelerant) and labor costs. These two items comprise 90% of the added costs from spray drying, with the other 10%

[6] Indications are that filtration requires little labor time as it is highly automated, and none was listed by New Logic as an operating cost. To be conservative in estimating operating costs, one hour of labor time per day was assumed.

consisting of power (steam and electric) costs. The estimate of labor time required for spray drying (from SuperPro) is about 15.5 hours per day, given the large mass of maltodextrin (0.9 ton/day) required for the drying process. Given all this, the estimate of daily operating cost for spray drying of retentates is approximately $1,920/day.

The information in Tables 1 and 2 can be used to develop cost-effectiveness analyses for the filtration and filtration/drying technologies relative to the current method of disposing of OMWW, which is assumed to be trucking to third-party disposal sites. According to industry sources, trucking OMWW for disposal costs approximately $0.05/gal (Bolton). Any alternate technology which displaces trucking as a disposal method reduces current operating costs by this amount. If its average total cost per gallon of OMWW is less than $0.05/gal, the alternative technology is more cost-effective and saves money overall.

Table 3 provides such a cost-effectiveness analysis for producing wet retentates from filtering the OMWW stream, using the numbers from the first data columns of Tables 1 and 2. Given the average useful life of the 24,000 gal/day filtration system (which, according to New Logic, is 20 years), the total volume of OMWW treated over the lifetime of the system is 175.2 million gallons.

Table 3. Cost-effectiveness analysis for producing wet reverse osmosis retentates

		Discount rate		
		0	0.02	0.05
Direct Cost:	PV(lifetime cost)	$1,903,134	$1,697,410	$1,409,002
	lifetime OMWW treated (gal)	175,200,000	175,200,000	175,200,000
	PV(cost)/day	$26.70	$232.52	$193.01
	PV(cost)/gal OMWW	$0.0109	$0.0097	$0.0080
Avoided Cost:	Hauling cost ($/gal)	-$0.05	-$0.05	-$0.05
PV(net cost)	**$/gal OMWW**	**-$0.0391**	**-$0.0403**	**-$0.0420**

The present value of lifetime cost, with purchase of the system in year 1 and discounted operating costs over years 2-20, varies from $1.4 million with a 5% discount rate to $1.9 million with no discounting.[7] This translates to a present value of daily cost of about $193-261, and a present value of cost per gallon of OMWW treated of about $0.008-$0.011, again depending on the interest rate. These are quite low compared to the cost of trucking OMWW away (at $0.05/gal), so the net present value of the cost of producing wet retentates ranges from -$0.039 to -$0.042; put another way, producing wet retentates[8] appears to save money relative to the current disposal method.

Thus, there appear to be three advantages to OMWW filtration: 1) it is less costly than trucking OMWW away, 2) it preserves the option to derive further value streams from the retentates themselves; and 3) the RO permeate is essentially pure drinking water, which can be

[7] The discount rates of 2% and 5% are chosen for the analysis since they seem likely to bound the long term interest rate under current economic conditions. In general, the higher the discount rate, the lower the present value estimate.
[8] The reader will note that the operation being discussed is to produce wet retentates and near-pure water, without there being any well-developed markets at present for the retentates. No allowance has been made in the analysis for the possibility that the retentates might be trucked away; this is discussed at the end of the section.

reused in the milling process, thereby saving on the annual water bill. The analysis thus far has dealt with only the first of these 3 potential advantages of OMWW filtration.

Before turning to the second and third potential advantages, the cost-effectiveness of filtration and drying is considered, using the numbers in the second data columns of Table 1 and Table 2. Table 4 presents these results.

Table 4. Cost-effectiveness analysis for producing dried reverse osmosis retentates

		Discount rate		
		0	0.02	0.05
Direct Cost:	PV(lifetime cost)	$14,706,661	$12,611,495	$9,674,231
	Lifetime OMWW treated (gal)	175,200,000	175,200,000	175,200,000
	PV(cost)/day	$2,015	$1,728	$1,325
	PV(cost)/gal OMWW	$0.0839	$0.0720	$0.0552
Avoided Cost:	Hauling cost ($/gal)	$0.05	$0.05	$0.05
PV(net cost)	**$/gal OMWW**	**$0.0339**	**$0.0220**	**$0.0052**

Because the operating costs are so much higher with spray drying, the present value of lifetime costs is also higher, ranging from $9.7 – $14.7 million, for 5% discounting vs. no discounting. The corresponding present values of daily cost range from $1,325- $2,015, and the present value of cost per gallon of OMWW treated ranges from $0.055-$0.084.

When compared to the *status quo* disposal cost of $0.05 per gallon, the combination of filtration and spray drying is $0.005 - $0.034 higher. However, as noted earlier, the spray drying technology is an elective decision for treating OMWW, and presumably would only be made when there was a profit opportunity from doing so.

This section has found that filtration of OMWW alone (i.e., without spray drying), is cost-effective relative to trucking the waste stream away, and that the elective procedure of drying is not cost-effective. These results are obtained without considering the potential values from the retentates and water which result from filtration and, perhaps, drying.[9] They also ignore the possibility that the firm using filtration might have to pay to ship retentates away for disposal. Drawing on some numbers from Table 6, which is explained fully in Section 3, one can get a rough idea of how this affects the cost-effectiveness analysis.

The retentates from 2-phase milling average roughly 40% of the mass of the OMWW stream (with near-pure water being the rest), and the average for 3-phase milling is about 34%. Since the water recovered can be reused in the production process, in the worst-case scenario where millers filter OMWW to recover water and then pay to ship retentates away for disposal, they would have to pay disposal fees for 34%-40% of the OMWW mass, rather than the entire mass.[10] This would mean that the cost savings of $0.05/gal OMWW would be realized on only 60-66% of the OMWW stream, which is equivalent to reducing the cost savings for <u>all</u> OMWW to $0.03-$0.033/gal. Even in this circumstance, it appears that filtration alone offers a cost-effective means of treating OMWW, though the margins would be slim. It seems likely that this would represent only a short-term situation, while millers await the development of products and markets for products from the retentate streams.

[9] These are taken up in sections 3-6.

[10] This is a conservative estimate, since process flow diagrams for OMWW filtration in both Europe and California indicate that, by volume, retentates comprise only 20% of the OMWW stream (Arviniti *et al.* 2012; New Logic). Trucking fees based on volume, rather than mass, would generate correspondingly higher cost savings.

3. Mass balance and industry-scale production from OMWW filtration

This section presents the basic mass-balance relationships used in sections 4-6 to provide some very rough looks at the prospective values that might be derived from the OMWW stream, considering the (limited) market information for wet and dried retentates, along with the value of water recovered and reused in the filtration process. To do this, an industry-scale mass balance analysis that explains the fractions of the OMWW stream that wind up as UF retentates, RO retentates, and RO permeate (which is near-pure water) is required. Since there are no industry-scale operations at present, we draw on both lab-scale work done at the UC Davis Olive Center and on an industry-scale (24,000 gal/day) process flow diagram from a prominent equipment manufacturer (New Logic).

The UC Davis work provides the mass fractions based on filtration results from samples of OMWW they drew from 3 California mills (which are designated as Mills A, B, and C) during the years 2013-14. The volume to scale up to industry scale is provided by the 24,000 gal/day New Logic process flow diagram.

The UC Davis lab-scale results are presented in Table 5, based on total solids measurements taken from OMWW filtration fractions from each of the mills during 2013 and 2014. This table illustrates the variation that one might expect in retentate and permeate fractions, based on the varieties of olives milled, the microclimate from which they come, and yearly weather variations, and type of milling operation.[11]

[11] There were technical difficulties with analyzing the 2014 Mill A samples, so mass fractions were not obtained. The 2013 results were used as a best estimate for Mill A’s 2014 mass fractions.

Table 5. Mass balances from OMWW filtration, by mill and year

Mass Balance	units	Mill A 2013	Mill B 2013	Mill C 2013	Mill A 2014	Mill B 2014	Mill C 2014
Pre-screened wastewater input feed	%[a]	100.00	100.00	100.00	100.00	100.01	100.00
UF retentate	%	18.99	13.92	25.34	20.25	20.53	25.34
RO retentate	%	15.03	15.55	9.13	27.99	28.83	9.13
RO permeate (near-pure water)	%	65.98	70.53	65.53	51.76	50.65	65.53

[a] Percentages of mass
Source: UC Davis lab analyses

Since Mill C is a 3-phase milling operation, while Mills A and B are (large and small, respectively) 2-phase operations, it makes sense to group the results by type of milling operation, so that the results presented are more specific to each type of mill. Table 6 presents this comparison, with the range of variation associated with the 2-phase mill operations.[12]

Table 6. Mass balances by type of milling operation

		Type of Milling Operation			
		2-phase values			
Mass Balance	Units	low	mean	high	3-phase
Pre-screened wastewater input feed	%	100	100	100	100
UF Retentate	%	13.92	18.42	20.53	25.34
RO Retentate	%	15.03	21.85	28.83	9.13
RO Permeate (near-pure water)	%	50.65	59.73	70.53	65.53

On average, the UF retentate and RO permeate fractions were higher for the 3-phase mill, while the RO retentate fraction was lower. For both types of mills, the largest fraction of the OMWW stream was recovered as near-pure water; this averaged 60% for the 2-phase mills and 66% for the 3-phase mill.

[12] Since there was only one year's worth of data for Mill C, there is no variation to report for 3-phase mills.

Table 7 scales up these results to industry scale, using the performance parameters of a 24,000 gal/day industrial UF and RO filtration system. The volume of OMWW treated per day is converted to a mass of OMWW, and the mass fractions from Table 6 are then applied. The resulting daily masses of UF retentate (UF-R), RO retentate (RO-R), and RO permeate (RO-R) are then calculated, and used for the prospective value analyses which follow in Sections 4-6.

Table 7 provides both the wet masses and dried masses of UF-R and RO-R, since there appear to be possible market channels for both. It is important to note that these are not additive; instead, they are equivalent masses that result from either not drying, or drying, the retentates from filtration.[13] In addition, the RO-permeate (near-pure water) is converted back from mass to volume at the end of the table, since the market prices for agricultural water are expressed on a per unit volume basis.

Table 7. Waste stream products from a 24,000 gal/day OMWW filtration system, by type of milling operation

	units	2-phase	3-phase
OMWW in	gal/day	23,904	23,904
OMWW in[a]	g/day	90,486,483	90,486,483
wet UF-R[b]	g/day	16,669,872	22,929,275
dried UF-R[c]	g/day	1,645,316	3,207,806
wet RO-R[d]	g/day	19,771,297	8,261,416
dried RO-R	g/day	1,951,427	1,155,772[d]
RO Permeate	g/day	54,047,576	59,295,792
RO Permeate	gal/day	14,278	15,664

[a] Converting from volume to mass using the density of water (3,785.41 g/gal)
[b] Using UF-R means from Table 2
[c] Using 2-phase (0.0987) and 3-phase (0.1399) UF solid content proportions
[d] Using RO-R means from Table 2

[13] The conversion factors from wet to dry retentates are based on Sheng (2015).

4. Relative retail values of OMWW dried retentate constituents

This section gives a sense for the relative potential values of the major constituents identified in OMWW, from analyses of the dried RO retentate. The important thing to bear in mind when reading the analysis of this section is that the values for constituent products are retail-level values, whereas the dried retentates are being produced at wholesale. There are one or more market levels between the two, with additional refining, purification, storage, transportation, and/or handling costs between the different market levels. This is why the indications of relative retail value of OMWW constituents does not translate closely to relative profitability to the olive miller.

In addition to the detailed UC Davis analysis of mass balances associated with OMWW samples from the 3 California mills during 2013-14, the samples were also dried and analyzed for their content of constituent phenolics and other notable chemical products by the Albany lab of the US Department of Agriculture Agricultural Research Service (ARS). These lab results are presented in Table 8, along with a scaling-up of the results to industry scale. The "constituent analysis" column contains lab results which were based on 1-gram samples, while the "industry scale" column projects the lab results to the expected amounts of each constituent with a 24,000 gal/day filtration and drying system. The scaling factor (1,951,427) is the mass of dried RO-R from Table 7. Retail prices are taken from searches of the website for Sigma-Aldrich, a major chemical supplier for scientific purposes, during July and August of 2015.

Table 8 presents the retail values of the phenolic and other constituents identified from the Albany lab analysis of 2-phase mills. The most highly-valued constituent, 3-hydroxytyrosol, was not found in the 2-phase samples, but a substantial amount of tyrosol provides the vast majority of daily retail value of constituents ($1,377 of a daily total of $1,446).

Table 8. Retail values of constituents identified in OMWW from California 2-phase mills

Item	units	Relative Quantities: Constituent Analysis[a]	Relative Quantities: Industry Scale[b]	Retail Price [c] ($/g)	Retail Value ($/day)
In: Dried RO Retentate[d]	g	1 g	1,951,427		
Out: *p*-coumaric acid	μg	8 μg	15.61	$3.42	$53.33
Out: tyrosol	μg	71.3 μg	139.14	$9.90	$1,377.45
Out: vanillic acid	μg	23.2 μg	45.27	$0.35	$15.70
Out: 3-hydroxytyrosol	μg	0 μg	0.00	$6,720.00	$0.00
					$1,446.48

[a] USDA lab results
[b] Using total 2-phase RO-R from Table 9
[c] *Source*: Sigma-Aldrich
[d] Mass includes maltodextrin added to facilitate drying

Table 9 presents similar results for the sample from the 3-phase mill, which does contain 3-hydroxytyrosol. The relative mass of 3-hydroxytyrosol found is comparable to that of other major constituents (tyrosol and vanillic acid), and with its phenomenally high retail price[14], the daily retail value of the 3-hydroxytyrosol identified translates to $840,000, the overwhelming majority of the daily value of about $841,000. A note of caution, though, is that this calculation is made based on one sample from one 3-phase mill.

[14] 3-hydroxytyrosol is used as a standardizing agent to evaluate the purity of chemical samples.

Table 9. Retail values of phenolics identified in OMWW from California 3-phase mills

Item	Relative Quantities: Constituent Analysis[a]	Relative Quantities: Industry Scale (g/day) [b]	Retail Price [c] ($/g)	Retail Value ($/day)
In: Dried RO Retentate[d]	1 g	1,155,772		
Out: *p*-coumaric acid	24.5 µg	28.32	$3.42	$96.73
Out: tyrosol	138.7 µg	160.31	$9.90	$1,587.03
Out: vanillic acid	105.3 µg	121.70	$0.35	$42.19
Out: 3-hydroxytyrosol	108.1 µg	124.94	$6,720.00	$839,589.83
				$841,315.78

[a] USDA lab results
[b] Using total 3-phase RO-R from Table 3
[c] *Source*: Sigma-Aldrich
[d] Mass includes maltodextrin added to facilitate drying

Since this first glimpse at the relative value of constituents can be misleading, with unknown but probably large costs required to obtain the retail values indicated from the OMWW products under discussion, the following two sections look at the limited evidence on wholesale values of both wet and dried retentates from OMWW filtering.

5. Prospective wholesale revenues from wet retentates

The analysis of this section draws upon European literature on the wholesale values of wet UF and RO retentates, where it appears that a market will exist soon, if it does not at present. A team of European authors has published several studies that address the technical and economic issues involved with processing OMWW from 3-phase milling, using filtration among other approaches (e.g., Arvaniti *et al*. 2012, Zagklis *et al*. 2013). They provide estimates of the value to millers of UF retentate, which they argue is suitable for use in “nutritious” products such as fertilizer and animal feed, and for RO retentate, which they argue would go into “toxic” products such as herbicides.[15] These values are €100/ton (about $109/ton with current exchange rates) and €250/ton (about $273/ton).[16]

There are several issues associated with attempting to use these estimates in the California setting. First is that the OMWW stream in Europe is different from in California: the fractions going into retentates and water and the phenolic contents, to name two. Second, and more challenging, is that there will be additional, unknown costs associated with getting the OMWW to the entity wishing to purchase it, involving transportation at a minimum and quite possibly storage facilities as well. The first issue can be addressed reasonably well, since the retentate and water fractions for California OMWW are known (e.g., Table 6), and the phenolic concentrations in European OMWW are reported by Arviniti, and they have been measured for the California samples by the UC Davis/ARS team (and are discussed below)[17]. The second issue cannot be addressed adequately, since transportation, storage, and other costs of selling OMWW at the prices listed in Arviniti depend heavily on the type and extent of markets that develop; this should be kept in mind when assessing the wet retentate values developed below.

Table 10 presents the results of testing of phenolic content on the California olive samples by the UC Davis/ARS research team. The phenolic concentrations vary substantially between mills, milling processes, and years. The initial OMWW feed into UF (after a pre-screening to remove large debris) had concentrations ranging from 0.117 to 2.656 grams per liter, while the UF retentate had concentrations varying from 0.259 - 2.672 g/L. The UF permeate which was subjected to RO filtering had concentrations ranging from 0.018 to 0.850

[15] Arviniti *et al*. 2012 do not explain the basis for this classification, but it must be based on something other than phenolics concentration, which is higher in the UF retentate than it is in the RO retentate for their study.
[16] They attribute the data to an organization called AGRO, but it has not been possible yet to verify the information.
[17] One limitation is that the phenolics measured may consist of different compounds in the two studies, but this can't be assessed since only the total phenolics concentrations are reported in each study.

Table 11. A comparison of phenolic concentrations in the California samples with those reported in Europe

	Type of milling operation						
	2-phase			3-phase			
	min	**mean**	max	min	**mean**	max	**Europe** [a]
Prefilter permeate (= UF feed)	0.02	**0.13**	0.24	0.45	**1.55**	2.66	**5.08**
UF retentate	0.26	**0.44**	0.85	1.93	**2.3**	2.67	**4.16**
UF permeate (= RO feed)	0.02	**0.03**	0.05	0.13	**0.49**	0.85	**5.04**
RO retentate	0.03	**0.23**	0.43	0.69	**0.91**	1.13	**0.90**
RO permeate	0.00	**0.00**	0.00	0.00	**0.00**	0.00	**0.01**

[a] **Arviniti *et al.*** 2012

Perhaps the best way of using this information on European price and the phenolic concentrations to infer a prospective price for California OMWW retentates is to develop “phenolics-equivalent” prices, which standardize on the relative phenolic content of the California samples. Table 12 provides the basic data used in this process.

Table 12. Determining American phenols-equivalent prices for wet retentates

Item	2-phase wet UF-R	2-phase wet RO-R	3-phase wet UF-R	3-phase wet RO-R	units
European price	€ 100[a]	€ 250 [a]	€ 100	€ 250	€/ton
Phenolics ratio	0.10	0.25	0.55	1.01	-
Phenolics-equivalent European price	€ 10.49	€ 63.13	€ 55.35	€ 252.78	€/ton
Exchange rate	1.09	1.09	1.09	1.09	$/€
Phenolics-equivalent American price	$9.63	$57.91	$50.78	$231.91	$/ton

[a] Arviniti *et al* analyze 3-phase milling, and the prices they report presumably are for 3-phase retentates from European olives. In the absence of any better information, we assume that these prices serve as a basis for determining California-equivalent retentates prices for both 2-phase and 3-phase milling. Effectively, the *concentration* of phenolics is accounted for in our adjustment, but not necessarily any important differences in the *composition* of phenolics.

With the European prices for wet retentates (the first line of Table 12) as a starting point, the phenolics ratio is calculated as the ratio of mean California phenolic content to the European mean content (both from Table 11), as it varies by type of milling process. These ratios vary from 0.10 for 2-phase wet UF-R to 1.01 for 3-phase wet RO-R. Multiplying these ratios by the European prices gives California (phenolics-adjusted) prices expressed in euros. Dividing these by the dollar-euro exchange rate then expresses the California prices in dollars.

The phenolics-adjusted prices range from about $10/ton for the 3-phase wet UF-R, about 10% of the corresponding European price, to $230/ton for the 2-phase wet RO-R, essentially equal to the European price. The reason for this is two-fold: the difference in phenolics concentrations between Europe and California, and the difference in values of their currencies.

The prospective revenues from wet retentates are then obtained by multiplying the daily masses of retentates expected from a 24,000 gal/day filtration system applied to OMWW from the two types of milling operations (Table 7) by their corresponding phenolics-adjusted prices from Table 12. Table 13 presents the estimates of these values, converting the masses in g/day from Table 7 to tons/day so that they are commensurate with the units of phenolics-adjusted prices.

Table 13. Prospective revenues from wet retentates

Item	2-phase wet UF-R	2-phase wet RO-R	3-phase wet UF-R	3-phase wet RO-R
Daily production (g/day)	16,669,872	19,771,297	22,929,275	8,261,416
Daily production (tons/day)	18.38	21.79	25.28	9.11
Phenolics-equivalent price ($/ton)	$50.78	$231.91	$9.63	$57.91
Prospective revenue ($/day)	**$933.07**	**$5,054.19**	**$243.31**	**$527.39**

The prospective daily revenues from wet retentates are substantial, varying from just over $900/day to just over $5,000 per day. They are additive for each type of milling process (since each one produces both wet UF-R and wet RO-R; this means that the daily value of wet retentates could be as much as about $6,000 for 2-phase retentates and $770 for 3-phase mills. To emphasize, though, these are prospective revenues, and the potentially substantial costs associated with market development in order to realize those revenues cannot be addressed.

6. Prospective wholesale revenues from dried retentates

The other avenue for generating revenues from filtration retentates is to dry the retentate and sell the resulting dried mass, which will be referred to as a “powder.” There are two big advantages of assessing the prospective revenues from dried retentates. The first advantage is that the dried retentates are of similar form to substances currently being purchased by pharmaceuticals manufacturers in California and elsewhere, so markets currently exist and could be tapped into. The second advantage is that the product sold at wholesale is similar or identical to the dried retentate coming out of the drying process, so that there is relatively little extra cost that isn't considered (transportation of the product being perhaps the biggest one). As a result, the revenue calculated in this section is much more comparable to the costs of filtration and drying, and can be realized currently.

Pharmaceuticals companies have expressed some interest in acquiring such powders at wholesale, because the phenolics they contain have desirable anti-oxidant, anti-microbial, and antibiotic properties. In addition, as Table 9 shows, the powder contains other substances for which there is market value, notably 3-hydroxytyrosol.[18]

These powders often are priced based on their content of standardizing agents, of which 3-hydroxytyrosol is one. The retail price found at Sigma-Aldrich and used in Tables 8 and 9 is for a 98% 3-hydroxytyrosol standard, for example. Contacts with the pharmaceuticals industry suggest that wholesale prices for lower 3-hydroxytyrosol concentrations would be on the order of $30/kg for 1.5% 3-hydroxytyrosol and $465/kg for 15% 3-hydroxytyrosol.

A reasonable way of estimating the possible daily production of retentate powders with these 3-hydroxytyrosol concentrations is to determine the masses of each concentration that the daily production of pure 3-hydroxytyrosol would support (Takeoka). Then multiplying each of these masses by the wholesale price per unit mass generates an estimate of the prospective revenues from the dried retentates. Table 14 presents the results of applying this procedure, based on the daily 3-phase production of 3-hydroxytyrosol from Table 9.

[18] The analysis of this section appears to be more relevant for mills using 3-phase production of olive oil, since as Table 8 indicates, there was no 3-hydroxytyrosol found in the 2-phase mill OMWW samples. This may be a function of small sample size.

Table 14. Prospective revenues from dried 3-phase retentates

Item Produced	daily production (g/day)	wholesale price ($/g)	**daily revenue ($/day)**
Pure 3-hydroxytyrosol	124.9	---	---
1.5% hydroxytyrosol	8,329.3	0.03	**$249.88**
15% hydroxytyrosol	832.9	0.465	**$387.31**

Daily production of pure 3-hydroxytyrosol from a 24,000 gal/day 3-phase OMWW filtration and drying system is expected to be about 125 grams (Table 9). This is equivalent to 8.3 kilograms of 1.5% 3-hydroxytyrosol or 833 grams of 15% 3-hydroxytyrosol. The wholesale prices noted above are $0.03/g and $0.465/g; this means that the prospective daily revenue from producing dried retentate powders would be about $390.[19]

7. Prospective values of the water recovered and reused from OMWW filtration

The final product from OMWW filtration that has apparent economic value is the near-pure water recovered, which can be reused in the milling operation or used elsewhere. An important consideration for millers is the ability of continuous reuse to reduce the effective stock of water needed for season operations. With the prospect of continued drought in California, this is a very attractive feature of the OMWW filtration process.

There are two ways to look at the economics of this issue – one based on money (contingent, of course, on current prices, which vary widely depending on how water is used in California, and may change in the future) and the other based on volumes saved, which is a potential selling point of adopting forward-looking resource-saving technologies. The reason

[19] Based on the two price estimates available, the price of powder increases at an increasing rate for higher 3-hydroxytyrosol concentrations. Presumably the miller would choose the concentration level that yielded higher daily revenues, all else equal.

Table 15. Prospective values and effective stock size of the reverse osmosis permeate, for reuse fractions of 0.90 and 0.75

	Type of mill		Type of mill	
Item	2-phase	3-phase	2-phase	3-phase
Reuse fraction	0.90	0.90	0.75	0.75
Daily water use and savings:				
OMWW input feed	24,000	24,000	24,000	24,000
RO permeate	14,335	15,727	14,335	15,727
RO permeate reduction	12,902	14,154	10,751	11,795
Yearly water use and savings:				
OMWW input feed	8,760,000	8,760,000	8,760,000	8,760,000
RO permeate	5,232,348	5,740,428	5,232,348	5,740,428
RO permeate reduction	4,709,113	5,166,385	3,924,261	4,305,321
Yearly savings:				
Gallons reduced	4,709,113	5,166,385	3,924,261	4,305,321
Acre-feet reduced	14.45	15.86	12.04	13.21
Value of water savings (water price = $200/af [a])				
Per year	$2,890	$3,171	$2,409	$2,643
Per day	$7.92	$8.69	$6.60	$7.24

[a] Unit is acre-feet; price is based on Hanak and Stryjewski and Vossen *et al*.

The value of water saved, at current agricultural water prices, is not large relative to the other costs (and cost savings) from OMWW filtration, since water cost is a low part of the operating costs. Several considerations suggest that this may not be true in the future, since the current value of water in California varies a great deal depending on how it is used. It may turn out that OMWW recycled water can be used in other than other than agricultural purposes; or that market renovations may cause water in different uses to be more equally valued (which is not the case at present); or that climate change will result in substantially increased values of water over time.

In light of these considerations, one can get a rough idea of the difference that this would make to the economics of OMWW filtration by valuing the water saved at higher prices.

If, for example, one chose the current retail municipal price of water to value the water (which itself varies substantially, but a price of $1,000 per acre-foot is well within the range of current California municipal rates), the daily and yearly savings from OMWW filtration would be approximately 5 times the values reported in Table 15. Even so, the water value saved would not be a large economic benefit to millers adopting filtration of OMWW: per-day values of OMWW saved would range between $30 and $40. Nonetheless, adoption of the technology would, at a minimum, be a positive talking point for millers.

8. Conclusion

The results of this analysis suggest a guarded but generally optimistic view of the eventual economic viability of OMWW filtration and drying. The positives include the fact that production of wet retentates appears to be cost-effective relative to a major current disposal option for OMWW – trucking them to third-party sites. In addition, markets for two of the major products from OMWW filtration and drying – near-pure water and dried retentates – are relatively well-developed and appear to offer opportunities for olive millers with a minimum of changes to their current production procedures aside from adding the filtration (and, possibly, drying) equipment.

Given the high cost of drying retentates and prices of retentate powders, however, it is not clear that producing dried retentates would be profitable currently as a strategy for dealing with the OMWW disposal problem. Though the comparison has not been made explicitly in the earlier sections, because they are somewhat disparate, it is worth discussing briefly the prospective benefits and costs of drying retentate in concluding. According to Table 4, in considering only the cost-effectiveness of filtering and drying retentates relative to trucking solids.

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Section: Food Engineering and Materials Science

Membrane-Filtered Olive Mill Wastewater:
Drying Techniques and Quality Assessment of the Dried Product

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Word count: 5,454 as of v3

Short version of title: Drying of Olive Mill Wastewater Filtration Fractions

ABSTRACT

A current trend in olive mill wastewater (OMWW) management is to not only decrease environmental pollution but also extract and utilize valuable by-products. Therefore, the objectives of this study were to explore different techniques for drying a phenolic-rich membrane filtration fraction of OMWW and compare the techniques in terms of the dried product quality and feasibility of the process. The OMWW from two (3-phase and 2-phase) California mills was subjected to a two-step membrane filtration process using a novel vibratory system. The reverse osmosis retentate (RO-R) is a phenolic-rich co-product stream, and the reverse osmosis permeate is a near-pure water stream that could be recycled into the milling process. Spray-, freeze-, and infrared-drying were applied to obtain solid material from the RO-R. Drying of the RO-R was possible only with addition of 10% maltodextrin as a carrier. The total soluble phenolics in dried RO-R were in the range 0.15–0.58 mg gallic acid equivalents/g of dry weight for 2-phase RO-R, and 1.38–2.17 mg gallic acid equivalents/g of dry weight for the 3-phase RO-R. Spray-dried RO-R from 3-phase OMWW showed remarkable antioxidant activity. Tyrosol, vanillic acid, and *p*-coumaric acid were quantified in all dried RO-R, whereas 3-hydroxytyrosol was found in 3-phase dried RO-R. Findings from this study show that drying of the membrane filtration stream of OMWW, especially spray drying, results in a powder that contains phenolics. This combination of separation and drying technologies helps to add value to an olive oil by-product and increase sustainability of its production.

Keywords: olive mill wastewater, membrane filtration, phenolics, drying

Practical Application

The results show the possibility to obtain a dried, phenolic-rich product after olive mill wastewater membrane filtration. This will lead toward better usage of by-products from olive oil production, an increase in the feasibility of the production, and lowering of the environmental impact.

Introduction

During olive oil production, large quantities of wastewaters and solid wastes are generated. The characteristics of olive oil waste are variable, depending on method of extraction, type and maturity of olives, region of origin, climatic conditions and associated cultivation/processing method (Paraskeva and Diamadopoulos 2006; Rahmanian and others 2014). Nowadays, two processes are used for the extraction of olive oil: 3-phase and 2-phase systems. Waste produced by the latter is composed of two main byproducts: an aqueous liquid known as olive mill wastewater (OMWW) and a solid waste (pomace) (Obied and others 2005). The newer 2-phase system produces semisolid waste known as alperujo (Fernández-Bolaños and others 2002) or sludge (Celma and others 2007), and small amounts of OMWW from the secondary centrifugation, generated during the washing and purification of virgin olive oil (Borja and others 2006).

OMWW is a dark, acidic matrix made up of water (83–94%), organic substances including carbohydrates, pectins, mucilage, lignin and tannins, lipids, and inorganic substances (Rahmanian and others 2014). However, from the perspectives of both human health and environmental impact, the most important components of OMWW are phenolic compounds, most of which are hydrophilic in nature, and thus remain in the water when portioned during olive oil processing (Rodis and others 2002). The concentration of phenolic compounds in OMWW ranges from 0.5–2.4 g/L (Paraskeva and Diamadopoulos 2006); many of these phenolic compounds are formed by the action of hydrolytic enzymes on olive secoiridoids, oleuropein and ligstroside, during oil extraction (Angelino and others 2011).

The phenolic composition of OMWW has been widely studied, and today more than 50 phenolic compounds have been isolated from olive mill waste (Obied and others 2007). Among them hydroxytyrosol and tyrosol are the most abundant compounds in OMWW (Obied and others 2005; Comandini and others 2015) followed by 4-methylcatechol, *p*-hydroxybenzoic acid, vanillic acid, syringic acid, gallic acid, catechin, apigenin, kaempferol, luteolin, quercetin, cyanidin, peonidin, nüzhenide, ligstroside, verbascoside, and some polymeric compounds (tannins and catecholmelanins) (Cardinali and others 2011).

OMWW is considered a highly polluting effluent due to its high organic load and phytotoxic/antibacterial phenolic substances, which are resistant to biological degradation (Cassano and others 2013). Thus, management, treatment, and disposal of produced waste raise serious environmental concerns. At the same time, extraction of the phenolic substances from OMWW has become important target since benefits of their bioactivity has been proven at all levels of *in-vitro*, *ex-vivo* and *in-vivo* studies (Jerman Klen and Mozetič Vodopivec 2011). Fortification of milk beverage with phenolic compounds extracted from OMWW (Servili and others 2011), and their potential use in the preparation of functional beverages (Zbakh and Abbassi 2012) confirm the application of OMWW phenolics in food products.

Several separation technologies have been applied for treatment of OMWW, though not many of them have found practical application in olive mills. A recent trend in OMWW management is to achieve both purification of the wastewater and concentration and extraction of phenolic compounds. For that purpose, membrane filtration technology showed promising results (Arvaniti and others 2012; Cassano and others 2013; Comandini and others 2015; Di Lecce and others 2014). Microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO) processes, mostly in sequential form, successfully meet the requirement for the recovery, purification and concentration of phenolic compounds from OMWW with regard to their specific molecular weight cut-off, and they reduce the polluting load of OMWW (Turano and others 2002; Paskareva and others 2007; Coskun and others 2010).

In this study, the OMWW from two California olive oil producers (3-phase and 2-phase) was treated with a novel vibratory sequential membrane filtration system, including UF and RO filters. The retentates and permeates were characterized, and the phenolic rich fraction – RO retentate (RO-R) was dried using spray-, freeze-, and infrared-drying. There is no available published data reporting on dried OMWW filtration fractions.

The objectives of this work were to investigate the possibility of drying a phenolic-rich membrane filtration fraction of OMWW, and to compare different drying techniques in terms of the dried product quality and feasibility of the process.

Materials and Methods

Materials

Olive mill wastewater was collected from 3- and 2-phase olive mills in California, USA in November 2013. Both mills processed Arbequina olives. OMWW from a 2-phase olive mill is wastewater obtained after second centrifugation step in the olive oil processing. OMWW samples were stored at -20 °C for further treatment and defrosted to room temperature before use.

Folin-Ciocalteu's reagent, 1,1-diphenyl-2-picrylhydrazyl (DPPH), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), gallic acid, 3-hydroxytyrosol, tyrosol, vanillic acid, and *p*-coumaric acid were obtained from Sigma-Aldrich (St. Louis, Mo., USA), while HPLC grade methanol and chemicals of analytical grade were purchased from Fisher Scientific (Pittsburgh, Penn., USA).

Membrane Filtration of OMWW

Two-step sequential membrane filtration of the OMWW samples was conducted on a VSEP vibratory membrane separation system, LP model (New Logic Research, Inc., Emeryville, Calif., USA). The system was equipped with a 37.9 L feed tank, an oil pump, a vibration motor, a single membrane plate (0.046 m^2 effective area), and feed circulation tubes. Based on preliminary testing, the ultrafiltration membrane PES-5/Tyvek (polyethersulfone, 7000 Da) was selected for the first step filtration to remove most of the suspended solids and large molecules. Process pressure was selected at 10.3 bar, and on average 30 mL/min flow rate. For the second filtration step, a reverse osmosis membrane ESPA (composite polyamide, 40 Da) was selected to purify wastewater and concentrate phenolic compounds. Process pressure was selected at 34.5 bar and flow rate at an average of 100 mL/min. Filtration parameters were determined by membrane selection, pressure selection, and trial run. Filtration started with one hour trial run in recirculation mode. If a flow rate stayed stable, the pressure would be kept. Otherwise, a different pressure would be applied. After a trial run, the system was set to separation mode. The permeate tube drained to buckets to collect the permeate. The flow rate, temperature, and pH value of the flow were monitored every 60 min. The filtration ended when the feed was concentrated to less than 3.79 L, which is the minimum operating volume for the system, or when a flow rate dropped below 10 mL/min. The system was cleaned and changed to a new membrane. Permeate from the first filtration was conducted to the feed tank for the second filtration with ESPA membrane. Second step filtration followed the same procedure as first step filtration. Samples from each filtration fraction were collected for analysis.

Physicochemical Properties of OMWW Filtration Fractions

Total solids (TS), dissolved solids (DS), and suspended solids (SS) were determined according to Standard Methods for the Examination of Water and Wastewater (APHA 2012).

Turbidity was determined using a turbidimeter (HI88703 Hanna Instruments United States Inc., Woonsocket, R.I., USA), while pH and conductivity were measured using a portable waterproof pH/conductivity meter (AP85 Accumet, Thermo Fisher Scientific Inc., Pittsburgh, Penn., USA).

Chemical oxygen demand (COD) was determined by the dichromate method. The appropriate amount of sample was introduced into commercially available digestion solution containing potassium dichromate, sulfuric acid and mercuric sulfate (High Range COD Reagent, LaMotte Company, Chestertown, Md., USA) and the mixture was then incubated for 120 min at 150 °C in a COD reactor (HI 839800, Hanna Instruments United States Inc., Woonsocket, R.I., USA). COD concentration was measured using a SMART3 colorimeter (LaMotte Company, Chestertown, Md., USA).

Total Soluble Phenolics and DPPH Radical Scavenging Activity

A procedure for total soluble phenolics (TSP) analysis was adapted from Swain and Hillis (1959) with slight modifications. After 1 g of sample was added into a 50 mL centrifuge tube, 20 mL HPLC grade methanol was added. Tubes were capped, vortexed for 15 s, and then stored at 4 °C overnight. The resulting homogenates were vortexed for 15 s, and then clarified by centrifugation (29000×g, 15 min at 4 °C) using a SORVALL RC 5C Plus centrifuge (Kendro Laboratory Products, Newtown, Conn., USA). A total of 150 µL of methanol extract was taken from the clear supernatant and then diluted with 2400 µL nanopure water, followed by 150 µL of 0.25N Folin-Ciocalteu reagent and incubated for 3 min at room temperature. The reaction was stopped by adding 300 µL of 0.5 mol/L Na_2CO_3 and the mixture was incubated for 25 min. Absorbance readings at 765 nm were taken using a Shimadzu PharmaSpec UV-1700 spectrophotometer (Shimadzu Scientific Instruments, Inc., Columbia, Md., USA). A blank prepared with methanol was used as control. The level of TSP for each sample was determined by using a standard curve developed with gallic acid (GA) (0–0.125 mg/GA mL) and expressed as mg gallic acid equivalents (GAE) per g of fresh and dry weight (mg/g).

2,2-Diphenyl-1-picrylhydrazyl radical ($DPPH^{\bullet}$) scavenging activity assay was based on the method of Brand-Williams and others (1995). $DPPH^{\bullet}$ scavenging activities in methanol extracts were expressed as mg of Trolox equivalents (TE) per 1 g of sample (fresh and dry weight basis).

Drying

RO-R was mixed with 10% maltodextrin (MD) (Dextrose Equivalent (DE) 18, Grain Processing Corporation, USA) volume/weight (w/v). Preliminary drying trials showed that drying of RO-R without addition of a carrier such as MD is not possible due to the low solids content of RO-R. Addition of 10% of MD was the lowest concentration necessary to obtain the dried powder.

The resulting dried material was packed in small bags (made of laminated foil and polyethylene films) with moisture sorption pouches and sealed. The samples were stored at ambient temperature until needed for analyses. The production recovery was calculated using the following equation:

Recovery (%) = mass of solid in the collecting vessel / mass of the feed x 100%

Spray Drying

The feed mixture comprising RO-R and MD was spray-dried in a pilot plant scale spray dryer (FT80 Tall Form Spray Dryer Armfield Inc., Jackson, N.J., USA). The spray drying conditions were as follows: inlet temperature 130°C, exhaust temperature 65 °C, relative humidity 7.1-7.9%, chamber pressure -1.66 mbar, cyclone differential pressure 5.8 mbar, feed pressure 0.21 bar, inlet fan (blower) 32 Hz, exhaust fan (ventilator) 36 Hz, feed pump 2.50 Hz.

Freeze Drying

The RO-R and MD mixture samples were pre-frozen and placed in a pilot scale freeze drier (VirTis Ultra 25EL-85, SP Industries, Gardiner, N.Y., USA). The freeze dryer was operated in shelf driven mode, which was controlled based on shelf temperature, and run with a programmed procedure. The programmed procedure lasted for 72 h, and included six drying steps (temperature from -20 °C to +20 °C, and vacuum from 500 to 200 mTorr).

Infrared Drying

Samples of RO-R and MD mixture were infrared dried with a Mathis Labcoater unit KTF-500 (Werner Mathis AG, Zürich, Switzerland). Prior to drying samples were pipetted on Teflon sheets. The sheets were placed on a Mylar sheet conveyor moving at 0.07 m/min. The samples were dried by an infrared heater adjusted to 70% and 0% infrared energy emission above and below the sample, respectively. The heating was set at 130°C, fan speed was 2000 rpm, and dwell time was 10 min.

Physicochemical Properties of Dried RO-R

Moisture content was determined gravimetrically using a vacuum oven method (AOAC 2006, Method 40.1.04).

Water activity (a_w) was measured at 25°C by the dew-point method with an AquaLab 4TE water activity meter (Decagon Devices, Pullman, Wash., USA).

Tristimulus (L*, a*, b*) color values were measured using a portable spectrophotometer (Model CM-508c, Konica Minolta Sensing Americas, Inc., Ramsey, N.J., U.S.A). Chroma was calculated by the formula $(a^{*2} + b^{*2})^{1/2}$.

TSP and $DPPH^{\bullet}$ scavenging activity of dried material were determined in the same way as described for the starting OMWW in *Total Soluble Phenolics and DPPH Radical Scavenging Activity*.

Quantification of Phenolic Compounds in Dried RO-R

Dried RO-R samples (4 g) were extracted two times with hexane and air dried. The defatted sample (1 g) was placed in a screw cap test tube with 5 mL of methanol. The mixture was sonicated for 10 min in a Branson 8200 ultrasonic cleaner (Branson Ultrasonics Corp., Danbury, Conn., USA). After 20 min, the mixture was sonicated for an additional 10 min. The sample was stored overnight in a refrigerator. The mixture was centrifuged and the sample was extracted two times with 5 mL aliquots of methanol (total of three extractions). The combined extract was collected and evaporated to dryness with a nitrogen stream. The residue was dissolved in 1 or 2 mL of methanol and stored in a refrigerator until HPLC analysis.

HPLC characterization of phenolic constituents in dried RO-R samples was performed on a Hewlett-Packard 1100 Series HPLC system consisting of an 1100 Series quaternary pump, an 1100 Series vacuum degasser, a manual injector (model 7725i, Rheodyne, now IDEX Health & Science LLC, Rohnert Park, Calif., USA), equipped with a 20 µL sample loop, an 1100 Series thermostated column compartment, and an 1100 Series diode array detector. The instrument was controlled and data were processed by an HP ChemStation for LC 3D (Rev. A.08.03 [847]). Analyses were conducted at room temperature using a 250 × 2.0 mm i.d. Synergi Hydro-RP column (4 µm, Phenomenex, Torrance, Calif., USA) equipped with an AQ C18 guard column (Phenomenex). Separations were carried out using a modification of a previously reported method (Comandini and others 2015). The extracts were syringe filtered through a 0.45 µm PTFE syringe filter before injection. Elution was performed using mobile phase A (0.1% formic acid in water) and mobile phase B (0.1% formic acid in acetonitrile). The gradient system was 0 min, 95% A; 27 min, 82% A; 50 min, 75% A; 72 min, 5% A and 77 min, 95% A. The flow rate was 0.2 mL/min. The detection was performed at 254, 280 and 320 nm. The phenolic compounds in dried RO-R derived from olive mill wastewater were identified by retention time and spiking extracts with phenolic standards. Quantification of phenolic compounds was performed by constructing standard curves of individual phenolic standards.

For LC-MS analyses an HP 1100 Series HPLC system including a G1379A degasser, a G1311A quaternary pump, a G1313A autosampler, a G1318A column compartment was used. The MS system was a Thermo Scientific LCQ Fleet ion trap mass spectrometer (San Jose, Calif., USA) with an electrospray ionization (ESI) source operated in negative ion mode. ESI voltage was 5 kV. The analytical column and gradient conditions were the same as used for the HPLC analyses. The flow rate was 0.2 mL/min. The mass spectrometer was scanned from m/z 120 to 1200. MS/MS spectra were obtained by collision induced dissociation (CID) using 35 eV.

Statistical Analysis

All analyses were performed in triplicate, and the mean values with the standard deviations are reported. Analysis of variance was applied, and P values < 0.05 were regarded as significant. The statistical data analysis software system MINITAB (Release 14, Minitab Inc., State College, Penn., USA) was used for analysis.

Results and Discussion

Filtration Process and Filtration Fractions Characterization

The membrane filtration process is presented as a flow chart diagram in Figure 1. The first step was a pre-screening procedure, where OMWW particles larger then 100 μm were separated. OMWW that passed the screen was regarded as an initial feed, and it was submitted to the vibratory membrane filtration unit. After passing the UF filter two fractions were obtained, UF retentate and UF permeate. The UF permeate was used as feed for RO filtration step, where RO retentate and RO permeate were generated.

The results of the physicochemical analyses of initial feed and four membrane filtration fractions for 3- and 2-phase OMWW are summarized in Table 1. The determination of total, dissolved, and suspended solids, turbidity, COD, conductivity, and total soluble phenolics (Tables 1 and 2) provided information about the efficiency of filtration processes. For all OMWW samples, there was a decrease in contents of above listed parameters for permeates and an increase in retentates. RO retentates had the highest concentration of total solids (8.2 and 5.3 times higher for 3- and 2-phase OMWW, respectively) compared to the corresponding feed (UF permeate). A similar trend was observed for the turbidity and conductivity measurements. COD, as a measure of organic pollutants, was dramatically decreased in the permeate fractions. The reduction of COD by 98% and 97% was achieved for 3- and 2-phase OMWW, respectively. Comandini and others (2015) determined slightly lower reduction of COD by 80% after UF and RO membrane filtration. These values are in accordance with the findings of Di Lecce and others (2014) who reported reduction of COD by 97% after UF and RO membrane filtration. pH value was the only tested parameter which was not largely affected by membrane filtration. Similar observations were reported by Di Lecce and others (2014) and Comandini and others (2015).

Due to the substantial differences in solids content among filtration fractions, results for TSP and scavenging activity on $DPPH^{\bullet}$ are calculated both for the fresh and dried material. As shown in

Table 2, the process of concentration of phenolic compounds by RO was more efficient in comparison to UF. In the 3-phase UF retentate concentration of TSP was increased 6 times compared to the initial feed, while in the RO retentate it was increased 9 times compared to the UF permeate. A similar trend was observed for the 2-phase OMWW fractions, where TSP content was increased 2 times by UF, and 9 times by RO. In both RO permeates TSP content was not detected. The efficiency of the RO membrane to retain phenolic compounds is due to its small molecular weight (MW) cut-off (Mudimu and others 2012). Phenolic compounds found in OMWW have low MW (MW=110-228 Da) and reduced molecular polarity due to aromatic rings (Galanakis 2015).

Antioxidant activity of OMWW filtrations fractions was determined by ability of methanolic extracts to scavenge the stable $DPPH^{\bullet}$. Changes in $DPPH^{\bullet}$ scavenging activity among 3-phase OMWW filtration fractions were similar to the TSP trend, while there were no statistically significant ($P < 0.05$) differences for 2-phase OMWW filtration fractions in their ability to reduce the initial concentration of $DPPH^{\bullet}$ (Table 2). Antioxidant activity of 3-phase OMWW membrane filtration fractions, determined by ABTS assay, was also in agreement with TSP results reported by Cassano and others (2013). Di Lecce and others (2014) reported a similar trend in scavenging activity of UF and RO fractions on ABTS radicals, but our results are not fully comparable because of differences in analytical methods.

Dried RO-R Characterization

Drying was applied to RO-R to reduce its moisture content and prolong its shelf-life. Compared with the liquid phenolic-rich fraction obtained after membrane filtration, the production of a dried fraction could result in lower storage and transportation costs, and also better storage stability. As mentioned earlier, drying of RO-R was possible only with addition of MD. Results of the drying process recovery, and moisture content, water activity, and color of the dried products are presented in Table 3. Among the tested drying techniques - spray drying (SD), freeze drying (FD), and infrared drying (IRD) - the highest product recovery was achieved for FD for both 3- and 2-phase RO-R. Furthermore, the moisture content of the dried RO-R was the lowest in FD samples.

Water activity (a_w) is an important parameter for dried materials because it can greatly affect their shelf-life. Food with $a_w < 0.6$ is generally considered as microbiologically stable (Quek and others 2007). The a_w values of the dried RO-R (Table 3) were in the range of 0.08–0.29, thus microbial stability was achieved for all dried RO. a_w of the FD 3-phase RO-R was significantly ($P < 0.05$) lower then that produced by SD and IRD. A clear relationship between a_w values of the dried 2-phase RO-R and the drying techniques was not observed.

The color properties of the dried material were significantly impacted by the drying techniques (Table 3). The following order in lightness (L* value is the degree of lightness to darkness) of dried RO-R was established: SD > FD > IRD for both 3- and 2-phase RO-R. Moreover, IRD samples were considerably more red (a* value is the degree of redness to greenness), and yellow (b* value is degree of yellowness to blueness) in color than FD and SD samples. Overall, color intensity of SD samples was remarkably lower, as showed by the lowest chroma values. Also, 3-phase RO-R samples had higher color intensity than 2-phase samples.

The appearance of dried RO-R obtained from 3- and 2-phase OMWW is shown in Figure 3. Besides the differences in moisture content, water activity, and color (Table 2), there was a prominent difference in texture of the dried products. SD samples were fine powder; FD ones were airy, light in weight; while IRD samples had the hardest crystal texture. The most acceptable appearance in terms of potential applications in nutraceuticals, feed or food products was achieved for SD.

Total Soluble Phenolics and DPPH Radical Scavenging Activity of Dried RO-R

Results for TSP content and scavenging activity on $DPPH^{\bullet}$ are shown in Figure 2. A significant ($P < 0.05$) difference in TSP content was observed among the different drying techniques. The highest TSP content was obtained by SD (2.17 and 0.58 mg GAE/g of dry weight for 3- and 2-phase RO-R, respectively), and the lowest was obtained by IRD. The same trend in TSP among drying techniques was noticed for both 3- and 2-phase RO-R. All extracts showed significant ($P < 0.05$) difference in their ability to reduce the initial concentration of $DPPH^{\bullet}$. Scavenging activity on this radical was 6 times higher for 3-phase than for 2-phase SD RO-R. The most striking result was that FD resulted in significantly lower TSP content and antioxidant activity than SD in both RO-R. FD usually preserves higher levels of TSP in comparison with drying at elevated temperatures (such as those used in SD), which might be attributed to the fact that heat-sensitive phenolics are degraded or biotransformed at high temperatures (Orphanides and others 2013). The presence of phenolic compounds in SD and IRD material may be explained with the fact that high temperature drying could inactivate the degradative enzymes such as polyphenol oxidases; therefore they were not able to degrade phenolic compounds during the drying procedures (Lim and Murtijaya 2007). Furthermore, Shofinita and Langrish (2014) observed that spray drying of orange peel extract did not significantly affect the phenolic content of the powder, and concluded that spray drying is a suitable process for drying heat-sensitive materials, such as phenolic compounds. Also, good antioxidant activity of spray-dried Gac fruit aril powder was reported by Kha and others (2010).

High operation cost and duration of FD in comparison to SD and IRD, as well as a lower TSP content in freeze-dried product, may be discriminating factors for this drying technique in industrial scale production of dried RO-R.

Phenolic Compounds in Dried RO-R

Phenolic compounds identified in dried RO-R are shown in Table 4. Phenolic compounds were detected at 254, 280, and 320 nm, and quantification was made at the highest absorption wavelength of each compound, while mass spectral data were used to identify phenolic compounds. According to the retention times and their spectral characteristics, tyrosol, vanillic acid, and *p*-coumaric acid were quantified in all dried RO-R, whereas 3-hydroxytyrosol was found in 3-phase dried RO-R. 3,4-Dihydroxyphenylglycol was tentatively identified by LC-MS. The early eluting compound (t_r = 4.93 min) had a ions at *m/z* 169 (100) and 339 (30). MS/MS of the *m/z* 169 ion gave a product ion with *m/z* 151 (100). The data was consistent with previous studies (Comandini and others 2015; Di Lecce and others 2014).

Hydroxytyrosol and tyrosol were reported as the main compounds in RO-R of 3-phase OMWW was reported by Comandini and others (2014), and (–)-epicatechin, (+)-catechin, ferulic acid, and oleuropein were detected at trace levels. According to Di Lecce and others (2014) the most abundant compound in NF retentate of 3-phase OMWW quantified was the oxidation product of elenolic acid, followed by tyrosol, hydroxytyrosol, protocatechuic acid and vanillic acid.

In dried RO-R 3-hydroxytyrosol and tyrosol were the predominant phenolic compounds (Table 4). The observed levels of hydroxytytosol, tyrosol, and *p*-coumaric acid content in 3-phase dried RO-R are in the same order of magnitude with the findings of Garcia-Castello and others (2010), who determined those compounds in 3-phase NF retentate, although different membrane filter was applied.

The trend in the phenolic compounds content determined by HPLC was in accordance to that obtained for the TSP determined by spectrophotometry. Among drying techniques, the highest concentration of the identified phenolic compounds was observed for spray-dried samples. The highest content of all identified compounds was established for 3-phase spray-dried RO-R.

The findings of this paper suggest the potential improvement in olive oil wastewater management through the two-step filtration process followed by a spray drying or infrared drying of the RO-R. Spray-dried RO-R samples from both 3- and 2-phase OMWW showed good quality in terms of process recovery, moisture content, water activity, and color properties. The total soluble phenolics content of 3-phase spray-dried RO-R and its scavenging activity on $DPPH^{\bullet}$ demonstrated that dried OMWW filtration fraction is a promising source of natural antioxidants. Further characterization of the dried material is needed for its possible applications in nutraceutical, feed or food industries.

Conclusion

The results of this study confirm that two-step (UF followed by RO) sequential membrane filtration can be successfully utilized in OMWW treatment. The obtained RO retentate is a phenolic-rich filtration fraction, and the RO permeate is a near-pure water that could be recycled into the milling process. The suggested combination of separation and drying technologies, and obtaining the dried material with concentrated phenolics, would have significant implication by-product usage. Recovery of phenolics from OMWW could help olive oil processors add value to their by-product, increasing the sustainability of its production.

Acknowledgment

This work is a part of the Specialty Crop Block Grant Program - SCB12040, supported by the California Department of Food and Agriculture. OMWW samples were generously donated by California Olive Ranch (Artois, Calif., USA) and Séka Hills (Brooks, Calif., USA).

Disclaimers

Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. U.S.D.A. is an equal opportunity employer.

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Table 1 – Physicochemical properties of the initial feed and fractions produced by UF and RO filtration of OMWW

3-phase OMWW	TS (%)	DS (%)	SS (%)	Turbidity (NTU)	COD (g/L)	pH	Conductivity (mS)
Initial feed	3.73 ± 0.02^{b}	2.99 ± 0.05^{c}	3.01 ± 0.08^{b}	13983 ± 60^{b}	50.5 ± 0.17^{b}	5.46 ± 0.01^{c}	4.54 ± 0.05^{c}
UF retent.	12.8 ± 0.06^{d}	6.60 ± 0.24^{e}	8.27 ± 0.19^{c}	46633 ± 756^{c}	220 ± 0.16^{d}	5.04 ± 0.08^{a}	11.4 ± 0.04^{d}
UF perm.	0.66 ± 0.04^{a}	0.69 ± 0.02^{b}	n.d.	3.43 ± 0.03^{a}	8.99 ± 0.05^{a}	5.22 ± 0.02^{b}	2.46 ± 0.02^{b}
RO retent.	5.39 ± 0.04^{c}	5.68 ± 0.03^{d}	0.02 ± 0.00^{a}	28.4 ± 2.5^{a}	68.1 ± 0.16^{c}	4.99 ± 0.03^{a}	16.3 ± 0.17^{e}
RO perm.	n.d.	0.01 ± 0.00^{a}	n.d.	0.32 ± 0.06^{a}	0.81 ± 0.00^{a}	5.59 ± 0.03^{d}	0.08 ± 0.00^{a}
2-phase OMWW							
Initial feed	0.35 ± 0.02^{b}	0.29 ± 0.01^{b}	0.08 ± 0.00^{a}	1014.3 ± 7.5^{b}	5.45 ± 0.11^{c}	7.15 ± 0.03^{d}	0.87 ± 0.00^{b}
UF retent.	1.59 ± 0.09^{d}	0.72 ± 0.00^{c}	0.94 ± 0.08^{b}	11416 ± 20^{c}	27.4 ± 0.41^{e}	6.70 ± 0.01^{c}	2.54 ± 0.02^{d}
UF perm.	0.16 ± 0.03^{a}	0.16 ± 0.01^{a}	n.d.	5.80 ± 1.00^{a}	1.59 ± 0.04^{b}	6.75 ± 0.03^{c}	0.47 ± 0.00^{a}
RO retent.	0.86 ± 0.01^{c}	0.84 ± 0.00^{d}	n.d.	9.03 ± 0.2^{a}	9.87 ± 0.67^{d}	6.46 ± 0.01^{b}	2.36 ± 0.03^{c}
RO perm.	n.d.	n.d.	n.d.	0.48 ± 0.17^{a}	0.16 ± 0.02^{a}	5.27 ± 0.06^{a}	n.d.

Values are means of three determinations ± standard deviation. Values in each column with the same superscript are not significantly different ($P < 0.05$). n.d. – not detected

Table 2 – Total soluble phenolics, and $DPPH^{\bullet}$ scavenging activity of OMWW filtration fractions

3-phase OMWW	TSP (mg GAE/g)	TSP/dw (mg GAE/g dw)	$DPPH^{\bullet}$ (mg TE/g)	$DPPH^{\bullet}$/dw (mg TE/g dw)
Initial feed	0.45 ± 0.01^{b}	11.9 ± 0.28^{a}	1.61 ± 0.06^{b}	43.1 ± 1.50^{a}
UF retent.	2.67 ± 0.07^{d}	20.9 ± 0.57^{c}	9.88 ± 0.18^{d}	77.3 ± 1.42^{c}
UF perm.	0.13 ± 0.00^{a}	19.1 ± 0.67^{b}	1.24 ± 0.02^{a}	188 ± 2.98^{d}
RO retent.	1.13 ± 0.01^{c}	21.0 ± 0.25^{c}	3.08 ± 0.05^{c}	57.1 ± 0.90^{b}
RO perm.	n.d.	n.d.	n.d.	n.d.
2-phase OMWW				
Initial feed	0.12 ± 0.00^{b}	33.4 ± 1.21^{d}	1.24 ± 0.05^{a}	354 ± 14.5^{c}
UF retent.	0.26 ± 0.01^{c}	16.3 ± 0.66^{a}	1.20 ± 0.08^{a}	75.5 ± 5.24^{a}
UF perm.	0.03 ± 0.00^{a}	21.7 ± 0.00^{b}	1.18 ± 0.05^{a}	738 ± 33.8^{d}
RO retent.	0.27 ± 0.00^{c}	31.1 ± 0.00^{c}	1.26 ± 0.07^{a}	146 ± 8.31^{b}
RO perm.	n.d.	n.d.	n.d.	n.d.

Values are means of three determinations ± standard deviation. Values in each column with the same superscript are not significantly different ($P < 0.05$). dw – dry weight, n.d. – not detected

Table 3 – Recovery, moisture content, water activity, and color of the dried products

Dried RO-R		Recovery (%)	Moisture (%)	a_w	Color			
					L*	a*	b*	Chroma
3-phase	SD	9.01 ± 0.62^{a}	5.84 ± 0.47^{b}	0.29 ± 0.01^{c}	88.5	-0.02	13.5	13.5
	FD	14.7 ± 0.88^{b}	4.57 ± 0.76^{a}	0.25 ± 0.00^{b}	74.6	3.40	22.5	22.7
	IRD	14.3 ± 0.56^{b}	5.24 ± 0.77^{ab}	0.23 ± 0.01^{a}	73.8	5.84	26.4	27.0
2-phase	SD	7.67 ± 0.22^{a}	4.38 ± 0.75^{b}	0.17 ± 0.01^{b}	89.8	0.51	6.75	6.8
	FD	9.37 ± 0.09^{c}	2.00 ± 0.04^{a}	0.08 ± 0.00^{a}	77.9	1.71	11.5	11.6
	IRD	8.49 ± 1.32^{b}	4.60 ± 0.26^{b}	0.18 ± 0.04^{b}	64.1	3.66	11.7	12.8

Values are means of three determinations ± standard deviation. Values in each column with the same superscript are not significantly different ($P < 0.05$)

Table 4 – Concentration of phenolic compounds in dried RO-R (μg/g dry weight)

Dried RO-R		3-Hydroxytyrosol (280 nm)	Tyrosol (280 nm)	Vanillic acid (254 nm)	*p*-Coumaric acid (320 nm)
3-phase	SD	108.1 ± 13.3	138.7 ± 23.6	105.3 ± 6.1	24.5 ± 5.1
	FD	35.2 ± 3.9	62.8 ± 7.6	33.5 ± 11.7	9.3 ± 1.2
	IRD	26.5 ± 1.5	44.9 ± 2.5	20.9 ± 4.3	6.7 ± 0.7
2-phase	SD	n.d.	71.3 ± 3.0	23.2 ± 1.6	8.0 ± 0.1
	FD	n.d.	32.8 ± 4.7	7.4 ± 1.7	5.4 ± 1.0
	IRD	n.d.	4.5 ± 0.5	2.8 ± 0.4	1.1 ± 0.2

Values are means of three determinations ± SD. n.d.-not detected

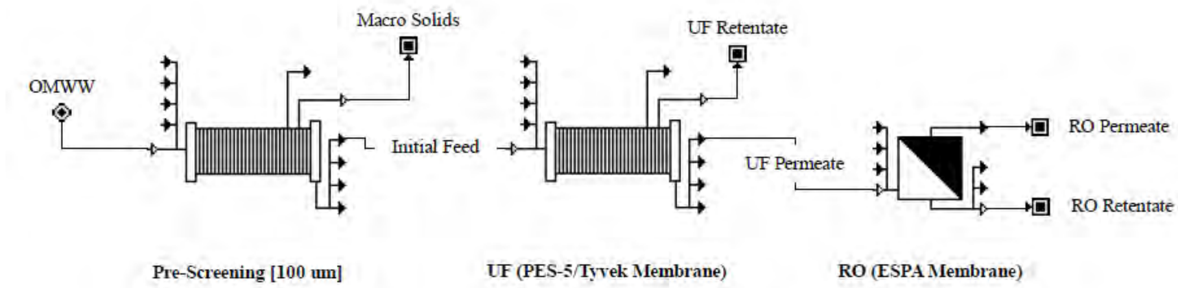


Figure 1 – Flow chart diagram of membrane filtration process

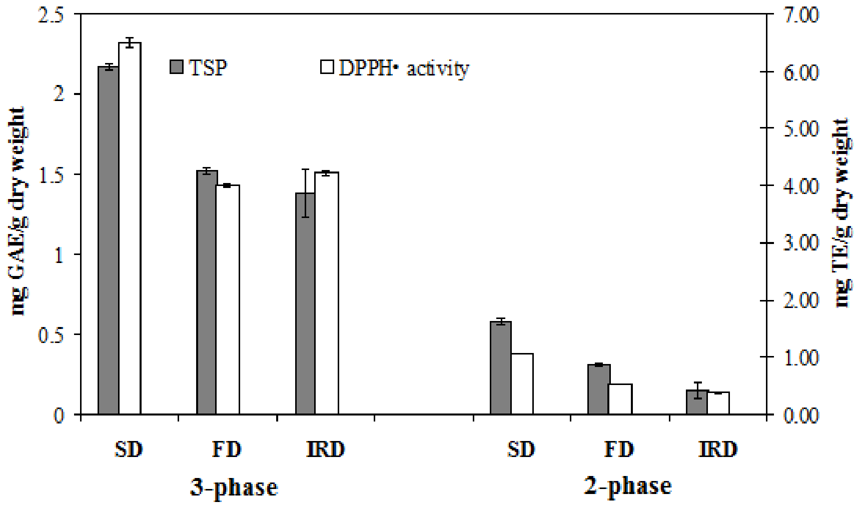


Figure 2 – Total phenolic content and scavenging activity on DPPH$^{\bullet}$ for dried RO-R. The error bars represent the standard deviations.

Figure 3 – Dried RO-R of 3-phase (Row a), and 2-phase (Row b) OMWW

Resistant test #1

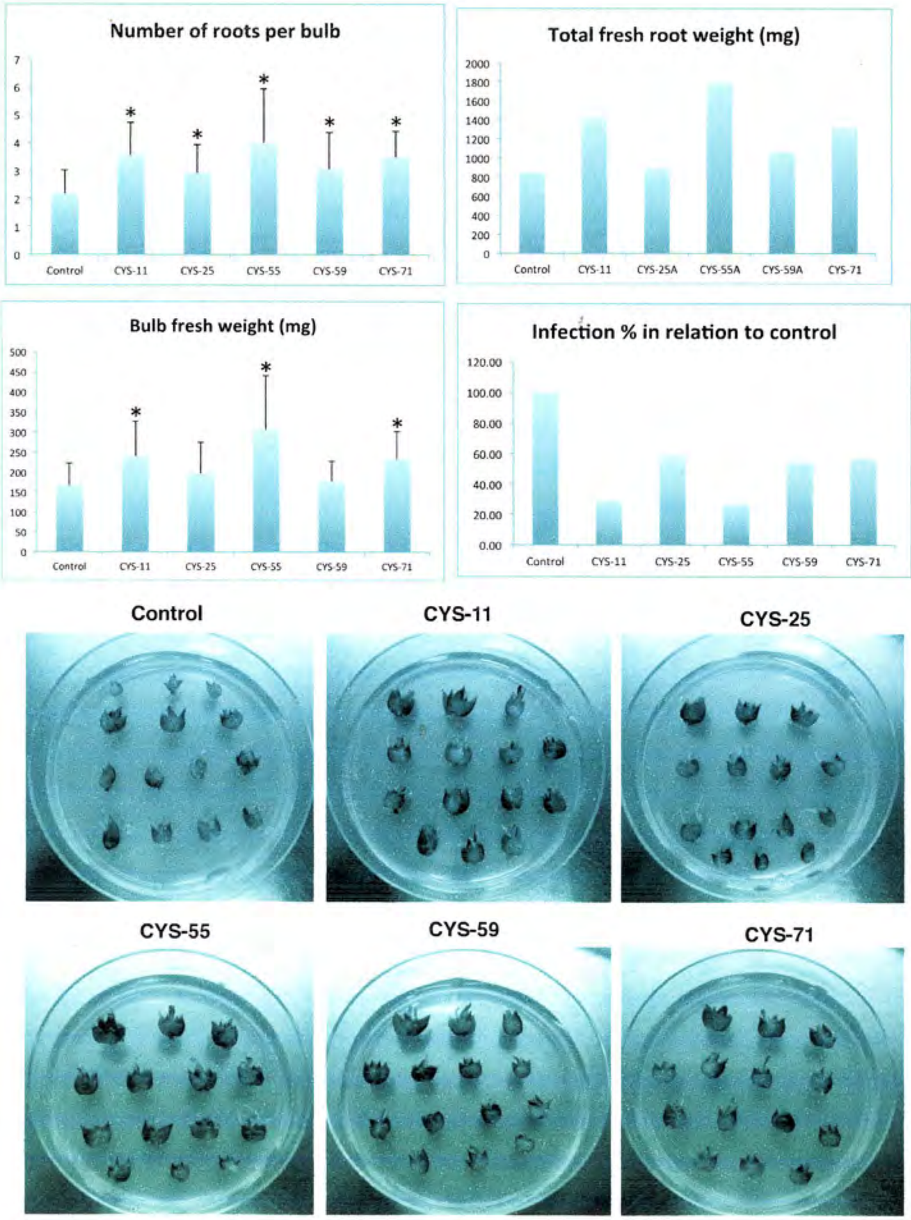


Figure 1. Characterization of CYS overexpression lily roots after nematode infection.

Resistant test #1: 16 bulbs were used.

Pairwise comparisons were made using Student's *t*-test ($P<0.05$) among each individual line and control.

Resistant test # I

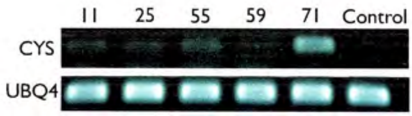


Figure 2. The CYS transcript levels of five different lines were examined by RT-PCR-based DNA gel blot analysis. A pool of roots from 5 different bulbs used for RNA extraction in each line.

Resistant test #2

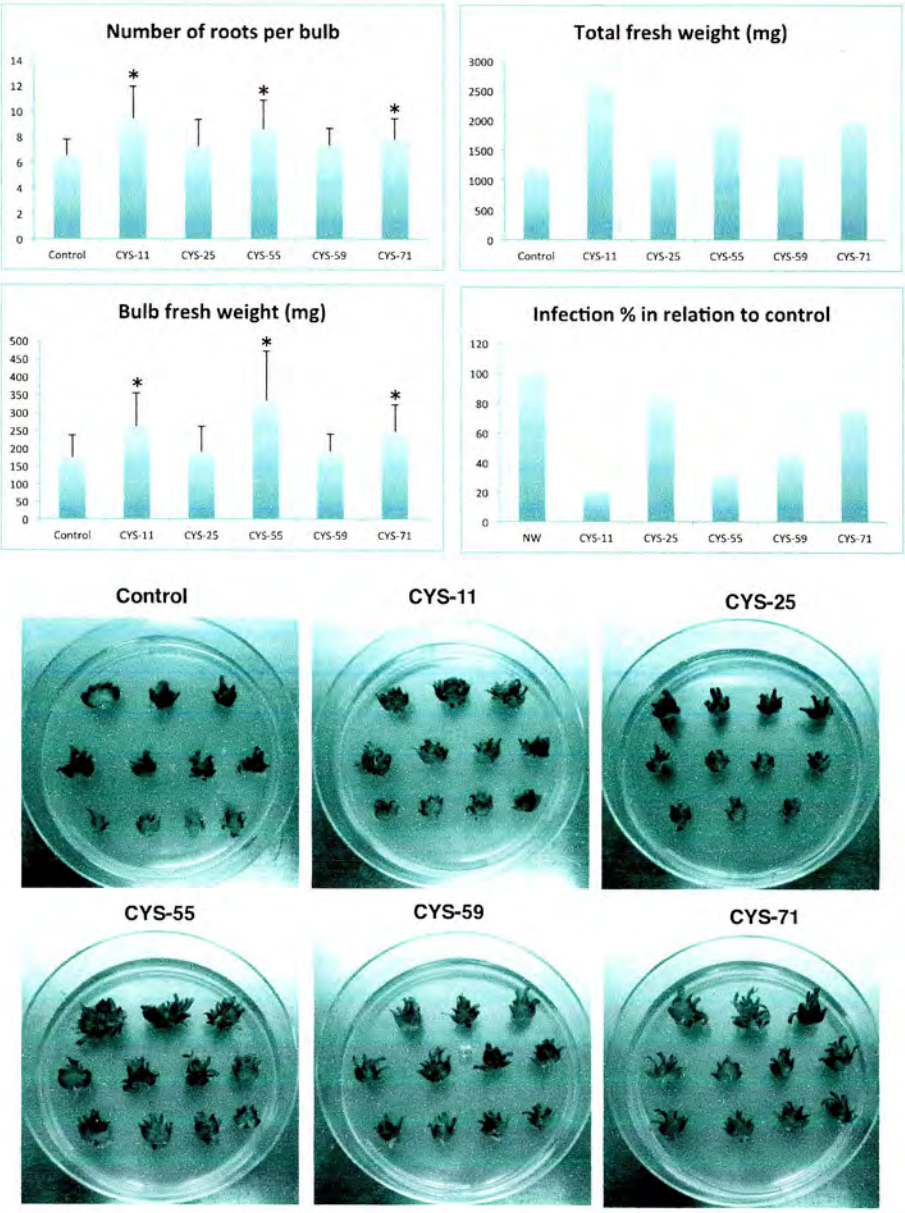


Figure 3. Characterization of CYS overexpression lily roots after nematode infection.

Resistant test #2: 12 bulbs were used.

Pairwise comparisons were made using Student's *t*-test (P<0.05) among each individual line and control.

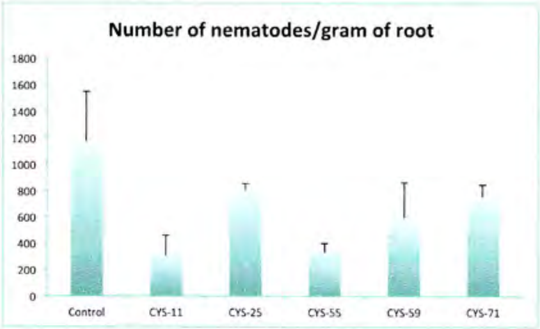


Figure 4. Number of nematodes per gram of root. Data shown represent means + SD from two independent biological tests (Resistant test #1 and Resistant test #2).

Resistant test #3

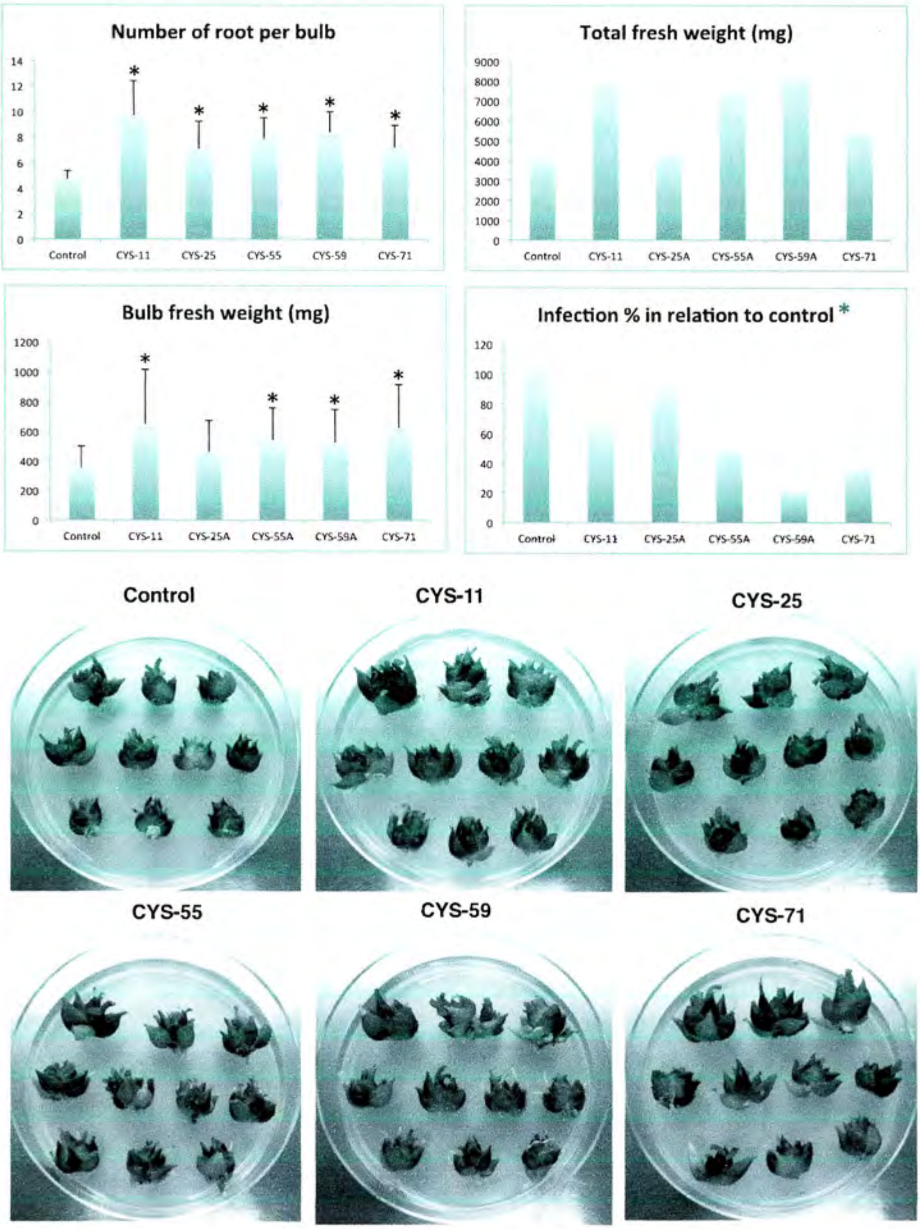


Figure 5. Characterization of CYS overexpression lily roots after nematode infection.

Resistant test #3: 18 bulbs were used.

Pairwise comparisons were made using Student's *t*-test ($P<0.05$) among each individual line and control.

***The number of nematodes collected for each line were low, which might influen the final results of this resistant test.**

Resistant test # 3

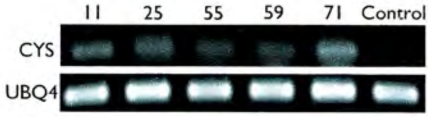
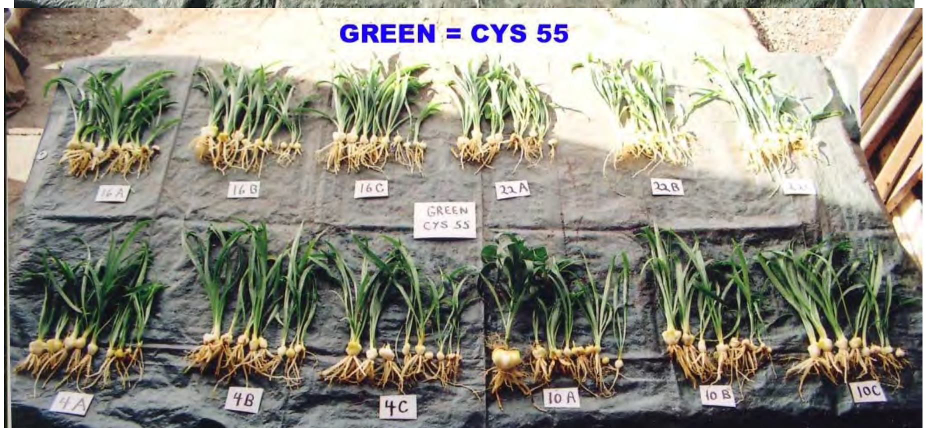
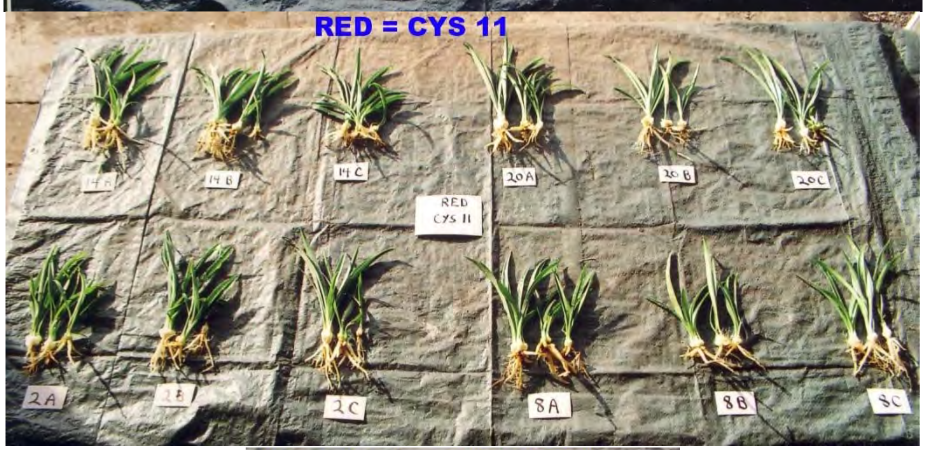


Figure 6. The CYS transcript levels of five different lines were examined by RT-PCR-based DNA gel blot analysis. A pool of roots from 5 different bulbs used for RNA extraction in each line.

USDA / UC DAVIS / ELRF 2014-15 NEMATODE RESISTANCE TRIAL


ORANGE = CYS 25
15A
15B
15C
ORANGE
CYS 25
21A
21B
21C
3A
3B
3C
9A
9B
9C


GREEN = CYS 55
16A
16B
16C
22A
22B
GREEN
CYS 55
4A
4B
4C
10A
10B
10C


RED = CYS 11
14B
14C
20A
20B
20C
RED
CYS 11
2A
2B
2C
8A
8B
8C


A LITTLE "RHIZOC"
5B

Transgenic Res
DOI 10.1007/s11248-014-9848-2

ORIGINAL PAPER

Expression of a cystatin transgene can confer resistance to root lesion nematodes in *Lilium longiflorum* cv. 'Nellie White'

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Received: 11 August 2014 / Accepted: 4 November 2014

Abstract *Lilium longiflorum* cv. 'Nellie White' assumes a great economic importance as cut flowers, being one of the most valuable species (annual pot plants value above $20,000,000) in terms of wholesales in the US. The root lesion nematode *Pratylenchus penetrans* (RLN) constitutes one of the main pests for lily producers due to the significant root damage it causes. Our efforts have focused on the generation of soybean hairy roots (as a transient test model) and stable transgenic lilies overexpressing a modified rice cystatin (*Oc-IΔD86*) transgene and challenged with root lesion nematodes. Lily transformation was achieved by gene gun co-bombardment using both a pBluescript-based vector containing the cystatin gene and pDM307 that contains a *bar* gene for phosphinothricin selection. Both soybean hairy roots and lilies overexpressing the *OcIΔD86* transgene exhibited enhanced resistance to RLN infection by means of nematode reduction up to 75 ± 5 % on the total number of nematodes. In addition, lily plants overexpressing *OcIΔD86* displayed an increase of plant mass and better growth performance in comparison to wild-type plants, thereby demonstrating an alternative strategy for increasing the yield and reducing nematode damage to this important floral crop.

Keywords Easter lilies · *Pratylenchus* · Cysteine proteinase inhibitor · Genetic engineering · Flower bulb crop

Electronic supplementary material The online version of this article (doi:10.1007/s11248-014-9848-2) contains supplementary material, which is available to authorized users.

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Introduction

Worldwide crop losses due to plant-parasitic nematodes have been estimated at $118 billion annually, with *Pratylenchus* spp. ranking third in terms of economic losses (McCarter 2009). The economic impact of *Pratylenchus* spp., commonly known as the root lesion nematodes (RLN), is due to their wide host range, comprising more than 400 species, including agronomically important crops (e.g., corn, wheat, rice, legumes, potatoes, sugarcane, cotton), ornamental plants (e.g., lilies, boxwoods, roses), and many fruit and nut trees (e.g., almond and walnut) (Castillo and Vovlas 2007).

Pratylenchus spp. are migratory endoparasitic nematodes that feed and migrate within the root cortical tissue causing a reduction in root growth after infection, accompanied by the formation of lesions, necrotic areas, browning and cell death (Jones and Fosu-Nyarko 2014), often followed by root rotting from secondary attack by soil fungi (Rotenberg et al. 2004) or bacteria (Vrain and Copeman 1987). *Pratylenchus penetrans* (Cobb, 1917) Filipjev and Schuurmans Stekhoven, 1941 infestations are particularly important in the production of Easter lilies (*Lilium longiflorum* Thunb.), as they cause great yield losses of this floral crop (Westerdahl et al. 1993). Disease symptoms on Easter lilies are generally characterized by stunted shoot and root growth and chlorotic foliage. In highly infested fields, lily plants may not even be able to emerge from bulbs, while in fields with moderate levels of RLN infestation, symptoms are not evident until late in the growing season (Westerdahl et al. 2003).

Currently, the most common strategies used for RLN control are genetic resistance, nematicide application, and rotation with non-host crops in an effort to limit the nematode population and nematode-related yield losses (Jones et al. 2013). Host resistance to *Pratylenchus* spp. is often limited, and only a few *loci* have been linked to resistance/tolerance to RLN, such as in wheat (Jayatilake et al. 2013; Williams et al. 2002), barley (Sharma et al. 2011), or *Medicago littoralis* (Oldach et al. 2014). Application of chemicals to control RLN is not a sustainable option, as most of these chemicals increase production costs and present negative effects on the environment.

In the past years, an increasing number of cystatin (cysteine proteinase inhibitor) genes have been isolated from numerous plant species (Benchabane et al. 2010; Martinez et al. 2012), and some of them have been exploited to develop transgenic crops resistant against sedentary (e.g., Chan et al. 2010; Lilley et al. 2004; Urwin et al. 2003), and in a few cases, migratory (Atkinson et al. 2004; Roderick et al. 2012) plant-parasitic nematodes. Inhibition of nematode digestive proteases by the uptake of cystatins from the host can produce profound effects on the nematode development and reproduction (Urwin et al. 2000). In the development of cystatin-based transgenic resistance, each candidate cystatin gene must be transferred into a susceptible host and the transformed roots tested for nematode resistance to determine which genes confer useful levels of resistance. Molecular modeling and amino acid sequence alignment can also assist in the design of site-specific mutagenesis to produce variant forms of cystatin transgenes (Atkinson et al. 1995). Among successful transformations, an improved engineered rice cystatin (*Oc-IΔD86*), an *Oc-I* variant that lacks the Asp86, has exhibited substantial effects in reducing infection by several economically important plant-parasitic nematodes, such as root-knot and cyst nematodes, the reniform nematode (*Rotylenchulus reniformis*) and the burrowing nematode (*Radopholus similis*) in a variety of food crops (e.g., banana, potato, rice, tomato) or *Arabidopsis* (Atkinson et al. 2004; Urwin et al. 1995, 1997, 1998, 2000; Vain et al. 1998).

Routine transformation has been achieved for many important economic crops but not ornamental floral crops, such as lilies. To date only four publications have reported successful transformation of ornamental lilies using genes other than the *uidA* (gus) reporter gene. Cohen and Krens (2012) and Mercuri et al. (2003) transformed *L. longiflorum* with *rol* genes in an effort to develop pollen-less plants. Two transgenic plants of *Lilium* x *formolongi* that expressed seven genes of the carotenoid biosynthesis pathway, as shown by their orange leaves, were recovered following *Agrobacterium*-mediated transformation (Azadi et al. 2010). *Lilium* cv. 'Acapulco' were transformed with a defective *Cucumber mosaic virus* replicase gene, and four plant lines were challenged and found to show increased levels of virus resistance (Azadi et al. 2011). Generally, the transformation efficiency of ornamental lilies is quite low making it very laborious to generate a population of transgenic plants, and this may be one reason why only a few transformation studies have used lilies. Wang et al. (2012) compared the *Agrobacterium*-mediated transformation efficiencies of eight ornamental lily cultivars, and the highest was 1.4 % for callus regenerated from filaments of the cultivar 'Santander'. Azadi et al. (2010, 2011) found a low 0.5 % transformation efficiency but were able to engineer expression of seven carotenoid genes. In comparison, they achieved a 36 % transformation efficiency when transforming with the *Cucumber mosaic virus* replicase gene.

In this study we used a genetically altered cystatin gene (*OcIΔD86*) to examine the potential use of such an approach in the production of lilies resistant against

RLN. Initially a transgenic soybean hairy root system was evaluated against *P. penetrans*, as this is a fast procedure to obtain transgenic roots and evaluate transgenes against nematodes (Li et al. 2010; Wubben et al. 2009). Transgenic lilies overexpressing *OcIΔD86* were generated and challenged with RLN. Overexpression of the *OcIΔD86* transgene in both soybean [*Glycine max* (L.) Merr. 'Williams 82'] hairy roots and lilies resulted in enhanced resistance to RLN infection by means of a reduction in nematode numbers, thereby providing evidence that results from hairy roots of soybean can be indicative of similar results in lilies. In addition, lily plants overexpressing *OcIΔD86* displayed increased plant mass and better growth performance in comparison to wild-type plants demonstrating an alternative strategy for increasing yield and reducing nematode damage to this important floral crop.

Materials and methods

Agrobacterium rhizogenes-mediated soybean hairy root transformation

The *Oc-IΔD86* transgene was previously generated from the *Oc-I* gene of *Oryza sativa* L. *japonica* and was cloned under control of the cauliflower mosaic virus (CaMV) 35S promoter to replace the GUS gene in the binary vector pBI121 (Urwin et al. 1995). The plasmid carries kanamycin resistance for selection in both bacteria and plants. To generate *35S:Oc-IΔD86* hairy root lines of soybean, the *Oc-IΔD86* construct was inserted into chemically competent *Agrobacterium rhizogenes* strain K599, while control hairy root lines were generated using *A. rhizogenes* harboring an empty vector (pBIN-JIT) that provides kanamycin resistance in both bacteria and plants (Ferrandiz et al. 2000).

Generation of soybean hairy roots was carried out according Cho et al. (2000). Briefly, soybean seeds were surface sterilized with 70 % ethanol for 10 min, 10 % bleach for 15 min, followed by four washes of sterile water for 5 min, and after drying placed on Murashige and Skoog (MS) medium (Murashige and Skoog 1962). Soybean cotyledons were excised from 7-day-old seedlings, and immersed in a 16 h culture of *A. rhizogenes* K599 suspension (LB medium containing 50 mg/l kanamycin). Excised cotyledons were then placed on MS medium for 3 days, and transferred afterwards to MS medium supplemented with kanamycin (200 µg/ml), carbenicillin (500 µg/ml) and cefotaxime (500 µg/ml). Within 2–3 weeks of incubation at 25 °C under dark conditions, individual hairy roots emerged on the surface of the cotyledons and were transferred to Petri dishes with MS supplemented with both carbenicillin (500 µg/ml) and cefotaxime (500 µg/ml). After about 6–8 weeks, the hairy roots were transferred for an additional four to five passages to fresh MS containing antibiotics, and then transferred to MS without antibiotics.

Lily transformation

Regenerable callus was induced from in vitro-grown plants of *Lilium longiflorum* 'Nellie White'. Plants were grown in Magenta jars containing MS medium supplemented with 3 % sucrose under light conditions. Bulb scales were cultured in the dark at 25 °C on MS medium supplemented with either 0.5 mg/l picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid), or 1.0 mg/l picloram, or 2.0 mg/l dicamba (3,6-dichloro-*o*-anisic acid) for callus production. Callus capable of plant regeneration was visually selected 3–4 months after bulb scales had been cultured on MS medium with 0.5 or 1.0 mg/l picloram and around 6 months when cultured on MS medium with 2 mg/l dicamba. Only selected callus was maintained until used for bombardment. A suspension culture was established by placing callus in liquid MS medium supplemented with 0.5 mg/l picloram. Suspension cultures were maintained in the dark on a gyratory shaker set at 120 rpm. All cultures were transferred to fresh medium once a month for 13 months prior to bombardment. Cells were subcultured by removing the liquid medium and transferring approximately half of the cells to a new 125 ml flask containing 30 ml of liquid MS medium with 0.5 mg/l picloram. Bulb scales were cultured on MS medium supplemented with 1.0 mg/l picloram for 3 days before their transfer to the same medium containing 0.125 M mannitol 4 days before bombardment (Kamo 2010).

Callus, suspension cells, and bulb scales of lily were co-bombarded with two plasmid DNAs using the PDS-1000/Helium system gene gun (Bio-Rad, Hercules, CA, USA). The modified cystatin gene under the control of the CaMV 35S promoter had been transferred along with the NOS terminator sequence from the pBI121 vector described above, to the pBluescript SK vector as a *Hin*d III-*Eco* RI fragment. Selection of plants was achieved using pDM307 (Cao et al. 1992) that contains the *bar* gene under the control of a CaMV 35S promoter and with a NOS terminator in pUC19. Both plasmid DNAs were isolated from *E. coli* strain DH5α using alkaline lysis followed by purification on a cesium chloride gradient (Maniatis et al. 1982).

The gene gun had a 1 cm gap and a 1 cm flying membrane distance, and a 12 cm target distance was used for bombardment. Gold particles (0.75 μm) were coated with both plasmid DNAs combined in equal amounts by weight and coated according to the method of Sanford et al. (1993). The morning of bombardment, callus and suspension cells were placed on MS medium containing the same hormone (either 0.5 or 1.0 mg/l picloram or 2.0 mg/l dicamba) that they had been growing on supplemented with 0.125 M mannitol and 0.6 % Phytoblend (Caisson Laboratories, North Logan, UT, USA). Callus and suspension cells were bombarded twice for each Petri plate at 900 or 1,100 psi, and each plate of bulb scales was bombarded once at 1,100 psi. Following bombardment, cells were transferred to the same MS medium and hormone that they had been growing on, but without the mannitol and solidified with 0.2 % Phytagel (Sigma-Aldrich, St. Louis, MO, USA). Cells were grown 1 week in the dark before their transfer to the same MS medium and hormone supplemented with 0.1 mg/l phosphinothricin (AgrEvo Co., Wilmington, DE, USA). One month later cells were transferred to the same MS medium and hormone supplemented with 1.0 mg/l phosphinothricin. Subculture to fresh selection medium continued for approximately 6–10 months. Shoots that regenerated from the callus were transferred to MS medium lacking hormones and supplemented with 1.0 mg/l phosphinothricin for three transfers on phosphinothricin before the selective agent was removed from the medium. Shoots were grown under a 12 h photoperiod using cool-white fluorescent lights (40–60 μmol/m^2/s).

PCR detection and RT-PCR analyses

Genomic DNA for PCR detection of the *Oc-IΔD86* transgene was extracted from 100 mg of fresh soybean hairy roots, or 200 mg of fresh lily roots, using the FastDNA kit (MP Biomedicals, Solon, OH, USA). Specific primers were designed for the detection of *Oc-IΔD86* in both soybean hairy roots and lily roots: CYS-F: 5′-TCAGACGGAGGACCAGTT-3′ and CYS-R: 5′-TCCCAAACTTTAGCTTCGTACA-3′. As controls, *Gm-UBQ3* (*Polyubiquitin* gene) gene-specific primers UBQ3-F: 5′-GTGTAATGTTG-GATGTGTTCCC-3′ and UBQ3-R: 5′-ACACAATT-GAGTTCAACACAAACCG-3′ were used for soybean hairy roots, while *Ll-UBQ4-F*: 5′-GGTATCCCTCCGGACCAG-3′ and *Ll-UBQ4-R*: 5′-ATGGTGTCCGAACTCTCCAC-3′ primers were used for lily roots (Yamagishi 2011).

Total RNA was isolated from 100 mg of fresh soybean hairy roots or 300 mg of lily roots using the RNeasy Plant Mini Kit (Qiagen, Valencia, CA, USA) following the manufacturer's instructions. The RNA was treated with RNase-Free DNase (Qiagen, Valencia, CA, USA) before reverse transcription. One microgram of treated RNA was added to the RT reaction using the iScript first-strand synthesis kit (Bio-Rad, Hercules, CA, USA) to produce cDNA. Semi-quantitative RT-PCR amplification to check the level of transcript expression of *Oc-IΔD86* in both soybean hairy roots and lilies was performed with the following PCR profile: 2 min at 94 °C; 35 cycles (30 s at 94 °C, 30 s at 58 °C, 30 s at 72 °C), and then one cycle of 72 °C for 10 min, using the primers mentioned above. The PCR reactions contained equal amounts of cDNA, 1× PCR buffer, 1 U Taq polymerase (Invitrogen) and 0.2 μM of each primer in a 50 μl total solution. PCR products were separated by electrophoresis on a 1 % agarose gel using TBE buffer (0.045 M Tris–borate, 0.001 M EDTA, pH 8.0) and visualized using ethidium bromide.

Acid fuchsin nematode staining

Roots at 3-weeks post nematode inoculation were stained with acid fuchsin following Byrd et al. (1983). Root tissues were destained by clearing solution (equal volumes of lactic acid, glycerol and distilled water) for 16 h. After rinsing several times with tap water, roots containing nematodes were stored in acidified glycerol (five drops of 1.0 M HCl in 50 ml of glycerol).

Nematode challenge assays

Sterile *Pratylenchus penetrans* (mixed stage population) were recovered from in vitro cultures of corn

(*Zea mays* L. cv. 'Iochief') roots maintained in MS medium. Nematodes were extracted by placing infected roots on a wire sieve in a sterilized glass bowl filled with distilled water containing 50 mg/l carbenicillin and 50 mg/l kanamycin. After 2 days, the sieve was removed and the solution containing the nematodes was poured into a 50 ml Falcon tube and centrifuged for 4 min at 4,000*g* and 4 °C. The supernatant was removed with a sterile 10 ml pipette, and the nematode pellet was then resuspended in sterile water containing 12 mg/l of Imazalil and both antibiotics mentioned above.

For nematode infection tests on soybean hairy roots, roots of 3–5 cm in length were excised from stock cultures and transferred to fresh MS plates without antibiotics. A total of seven *Oc-IΔD86* overexpressing lines were challenged with RLN using nine hairy root systems per line in each of two independent biological tests. Three control lines (containing an empty vector) were selected using nine hairy roots per line. Two weeks later, each hairy root system was inoculated with a mixed population of ~300 sterile *P. penetrans* and maintained in the dark at 25 °C. The host efficiency of lilies was evaluated in three independent biological tests, using bulbs (with an initial size of 1 cm diameter) cultured on MS medium without antibiotics for 1, 2 and 3 months, respectively. In each experiment a minimum of 16 bulbs growing in vitro were challenged. Each root system was inoculated with a mixed population of ~300 sterile *P. penetrans* and maintained in a growth chamber at 28 °C with a photoperiod of 16 h light/8 h dark. Approximately 2.5 months after inoculation, infected roots of both soybean hairy roots and lilies were chopped into small pieces and both roots and medium were placed into sterile glass bowls filled with sterile water containing 50 mg/l carbenicillin and 50 mg/l kanamycin. Nematodes were extracted 5 days later by sieving the water with a 500 µm mesh sieve. Data are expressed as the total mean number of nematodes ± SEM per fresh gram of root from two independent biological experiments for soybean hairy roots and three independent biological experiments for lilies, and are presented as the percentage of nematodes in comparison to the mean number of nematodes of control lines. All data were analyzed using analysis of variance (ANOVA), and means were compared using Tukey's honestly significant difference (HSD) test at the 5 % probability level.

Results

Production of transgenic soybean hairy roots overexpressing Oc-IΔD86 construct

A transgenic hairy root system induced via *Agrobacterium rhizogenes* was initially chosen to assay if overexpression of *Oc-IΔD86* transgene in soybean hairy roots could confer resistance against RLN. From a total of twenty hairy root lines showing resistance to kanamycin, a subset of seven independent lines (L1–L7) was chosen after PCR validation (Supp. Fig. 1a). A band of the expected size (236 bp) was amplified from all putative transgenic root DNA samples, whereas the negative control (genomic DNA extracted from wild-type soybean roots) showed no amplification of the *Oc-IΔD86* fragment (Supp. Fig. 1a). *Agrobacterium rhizogenes* containing an empty vector (pBIN-JIT) was used to generate control soybean hairy roots, which were validated using specific primers for the *nptII* (kanamycin resistance) gene, yielding a fragment of 700 bp (Supp. Fig. 1b).

The expression levels of *Oc-IΔD86* in the different cystatin overexpression lines were then evaluated by semi-quantitative RT-PCR, and different levels of expression were observed among the seven lines (Supp. Fig. 1c). Phenotypic analyses revealed no significant developmental alteration in root morphology or growth among both cystatin overexpression and empty-vector soybean hairy roots.

Evaluation of RLN development in cystatin transgene-overexpressing soybean hairy roots

To investigate the effect of overexpressing the *Oc-IΔD86* transgene on nematode infection and development, all seven cystatin-overexpressing lines and three control lines were challenged with RLN. Three weeks after RLN inoculation a random screening of infected roots ($n = 5$) showed that nematodes were able to penetrate and develop in both cystatin-overexpressing and control lines (Supp. Fig. 2).

The total number of nematodes supported by each line was then compared two-and-half months after nematode inoculation. Two independent nematode challenge assays were performed, and data are presented as the percentage of total nematodes recovered per fresh gram of root, in relation to the average nematode numbers obtained for three control lines

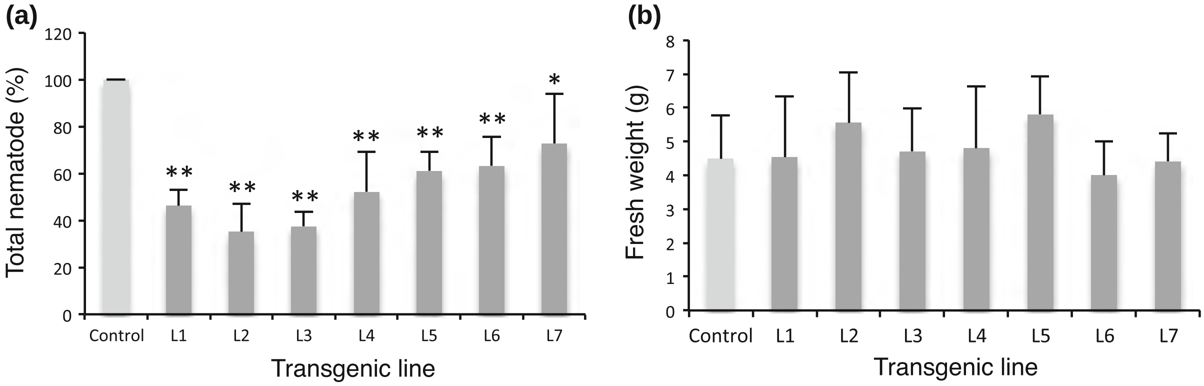

Fig. 1 Nematode challenge assays in transgenic soybean (*Glycine max*) hairy roots 2.5 months after inoculation. **a** Data shown represent the total mean nematode number ± SEM per gram fresh of root, from two independent biological assays, expressed as a percentage relative to the average total number for three empty vector control lines. *Asterisks* indicate values significantly different from the wild type (*$P < 0.05$; **$P < 0.01$). **b** Total fresh weight (g) of soybean hairy roots infected with RLN in two independent biological challenge assays

(Fig. 1a). Three out of seven cystatin lines (L1, L2 and L3) presented more than a 50 % decrease in nematode numbers in comparison to the control ($P < 0.01$). Although the remaining lines seemed to be less effective, these lines still displayed a >40–27 % reduction of the total number of nematodes, and were statistically different from control roots (L4, L5 and L6, $P < 0.01$; L7, $P < 0.05$). All soybean hairy root lines displayed a similar root fresh weight after nematode extraction (Fig. 1b).

Production of transgenic lily plants

The *Oc-IΔD86* transgene was cloned into a pBluescript-based vector under the control of the CaMV 35S promoter for gene gun bombardment. Callus/suspension cell cultures or bulb scales of *Lilium longiflorum* 'Nellie White' were transformed by gene gun co-bombardment using both this plasmid containing the cystatin gene and pDM307 which contains the *bar* gene for phosphinothricin selection. Callus was grown either on 0.5 mg/l picloram or 1.0 mg/l picloram, or 2.0 mg/l dicamba and bombarded at either 900 or 1,100 psi to determine the optimum treatment for transgenic lily production (Supp. Table 1). A total of 23 lines were validated by PCR analyses. The presence of the *Oc-IΔD86* transgene was confirmed for ten lines, showing a band of the expected size (236 bp) (Fig. 2a; Supp. Fig. 3a). Four transformed lily lines were isolated from eight plates of callus that had been cultured 3–10 months on 0.5 mg/l picloram before bombardment at 900 psi. Three additional lines were obtained from callus culture, however, only 5 plates of callus induced on MS medium with 2 mg/l dicamba were available for bombardment as compared to 19 and 13 plates of callus for 0.5 and 1.0 mg/l picloram, respectively, because there was not as much callus proliferation on 2 mg/l dicamba. One transgenic line was recovered from direct bombardment of 460 bulb scales. Two transgenic plants were recovered from suspension cells bombarded at 900 psi and three plants from 1,100 psi, respectively.

The *Oc-IΔD86* transgene expression levels were examined by semi-quantitative RT-PCR for the ten transformed lines (Fig. 2b; Supp. Fig. 3b), using a pool of roots collected from five plants per individual line to evaluate the transcript levels from the initial transformation. Five lines showing higher expression of *Oc-IΔD86* were selected for further assays (CYS-11, CYS-25, CYS-55, CYS-59 and CYS-71). Among these five lines, CYS-25 exhibited the lowest level of expression.

This was then repeated for five randomly selected bulbs per line after their propagation in vitro for several generations (Fig. 2c). The levels of expression among roots collected from individual bulbs presented similar patterns within each line, indicating that although plants were continuously maintained in MS culture and propagated vegetatively, the expression levels of the *Oc-IΔD86* transgene were stable, and the plants did not show evidence of being chimeric. All five lines exhibited a phenotype similar to that of non-

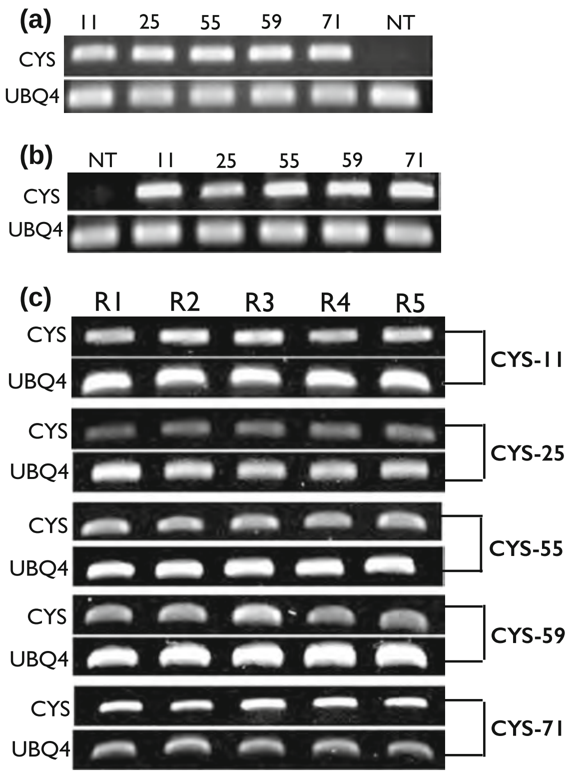

Fig. 2 Molecular characterization of transgenic lilies (*Lilium longiflorum*) overexpressing the *Oc-IΔD86* transgene. **a** Genomic PCR detection of the *Oc-IΔD86* transgene in five independent lily lines. No amplification was detected using DNA extracted from wild-type lily roots (non-transformed, NT) as a control. **b** The *Oc-IΔD86* transcript levels were examined by semi-quantitative RT-PCR visualized on an agarose gel stained with ethidium bromide. A pool of roots from 5 different plants was used for RNA extraction for each independent line. Amplification of Ll-UBQ4 was used as a control for verifying equal cDNA concentration. **c** *Oc-IΔD86* transcript levels in roots collected from individual bulbs (R1–R5) maintained in MS cultures and propagated vegetatively for several generations. Semi-quantitative RT-PCR was visualized on an agarose gel stained with ethidium bromide. Amplification of *Ll-UBQ4* was used as a control for verifying equal cDNA concentration

transformed plants (Supp. Fig. 4), when growing in vitro in our culture room at 25 °C and with a photoperiod of 12 h light/12 h dark.

Challenge of transgenic lilies with root lesion nematodes

Three independent nematode challenge assays were performed to test the levels of resistance of transformed lilies towards RLN infection, using 1-, 2- and 3-month plants growing in MS medium, respectively. A visual scoring of the emerged roots formed in each individual bulb 2.5 months after nematode infection revealed that lilies overexpressing the *Oc-IΔD86* transgene harbored a significantly higher number of roots when compared to wild-type plants (Table 1), with the exception of the CYS-25 line. Similarly, total root and bulb fresh weights were significantly increased relative to the values observed in wild-type plants (Table 1), these increases were reflected in healthier bulbs that grew more vigorously (Fig. 3) and showed a weaker impact of RLN infection on their growth performance than controls.

For total nematode quantification, control levels of infection were standardized at 100 % and compared to the relative percentage of nematodes recovered per gram fresh of root for each line, among the three independent assays (Fig. 4).

We observed a wide range of reduction (19 ± 12–75 ± 5 %) in the total number of nematodes associated with the different *Oc-IΔD86* overexpressing lines in comparison to wild-type lilies. The cystatin expression level as detected by semi-quantitative RT-PCR correlated with the number of nematodes established in each line, with CYS-25 showing the lowest reduction of nematode infection. Nevertheless, the number of nematodes established on the transgenic lily roots was significantly reduced ($P < 0.01$) for all cystatin expressing lines, with CYS-11 and CYS-55 lines showing the highest nematode reduction. These data indicate that reproduction was affected in RLN feeding on plants expressing the *Oc-IΔD86* transgene.

Discussion

All commercial field-grown lily species are susceptible to RLN (*personal communication*, Lee Riddle, manager of the Easter Lily Foundation, Smith River, CA, USA). In 2013, the wholesale value of all lily species sold as cut flowers in the US was $61,834,100, and the wholesale value of Easter lilies sold as pot plants was $23,525,000 (USDA Statistics Floriculture Crops 2014). Currently, there is an urgent need for control measures against such economically important nematodes. In this study, *L. longiflorum* ‘Nellie White’ was chosen because it has been the main cultivar grown in the US for many years. We selected the *Oc-IΔD86* transgene for generating transgenic lilies and

Table 1 Effects of root lesion nematode on cystatin overexpressing lily plants, based on root and bulb development, 2.5 months post-nematode infection

Line	Average number of roots/bulb			Total fresh root weight (mg)			Average bulb weight (mg)		
	Exp. 1 (n = 16)	Exp. 2 (n = 18)	Exp. 3 (n = 20)	Exp. 1 (n = 16)	Exp. 2 (n = 18)	Exp. 3 (n = 20)	Exp. 1 (n = 16)	Exp. 2 (n = 18)	Exp. 3 (n = 20)
WT	2.19 ± 0.83	4.72 ± 0.67	8.40 ± 2.46	848	4,080	9,900	168.31 ± 55.21	352.22 ± 149.3	498.00 ± 188.6
CYS-11	3.56 ± 1.15**	9.72 ± 2.70**	12.60 ± 2.54**	1,419	7,770	16,550	240.02 ± 89.07**	647.25 ± 364.6**	841.25 ± 255.4**
CYS-25	2.94 ± 1.00*	7.11 ± 2.17**	8.55 ± 1.79	901	4,370	10,030	198.13 ± 76.79	463.89 ± 212.5	552.5 ± 204.8
CYS-55	4.01 ± 1.93**	7.89 ± 1.68**	11.10 ± 2.86**	1,792	7,300	12,980	306.88 ± 133.30**	543.89 ± 211.2**	714.50 ± 357.4**
CYS-59	3.06 ± 1.29*	8.33 ± 1.71**	10.65 ± 2.18**	1,061	8,130	12,620	178.75 ± 48.56	529.44 ± 220.8**	762.00 ± 290.40**
CYS-71	3.5 ± 0.89**	7.22 ± 1.73**	11.25 ± 2.31**	1,320	5,300	13,310	234.38 ± 68.80**	627.22 ± 291.6**	748.50 ± 225.90**

Asterisks indicate values that were significantly different from the wild type (* $P < 0.05$; ** $P < 0.01$)

its inhibitory effect against root lesion nematodes was evaluated. Both engineered and native cystatin genes have provided resistance against a broad spectrum of plant parasitic nematode species, such as *Globodera pallida* (Urwin et al. 1995), *Heterodera schachtii* and *Meloidogyne incognita* (Urwin et al. 1997), and *Radopholus similis* (Roderick et al. 2012).

Initially we took advantage of *A. rhizogenes*-mediated transformation of soybean, because a hairy root system allows a fast generation of roots expressing a gene of interest, thereby allowing us to achieve a quick validation of resistance against RLN, despite the inherent variability of this technique (Plovie et al. 2003). Because generation of transgenic lily plants is time consuming due to the typically low frequency of transformation, the hairy root approach can be applied as a good model to predict resistance levels of candidate genes against RLN. It took 2 years to generate the ten lines of lilies containing the cystatin gene. Although there were 23 lines of putatively transformed plants, only 10 were found to contain the cystatin gene. The other 13 lines may have contained only the *bar* gene used for selection, as typically only 50–70 % of the transgenic plants recovered will contain both transgenes following co-bombardment (Kamo and Joung 2009).

Our first nematode trials using soybean hairy roots were in agreement with previous findings demonstrating resistance against *P. penetrans* in alfalfa containing full length *Oc-I* and *Oc-II*, which code for proteins of 17 and 12 kDa, respectively (Samac and Smigocki 2003). However, as shown for other nematode species, transgene-mediated resistance of *Oc-IΔD86* seems to confer higher levels of resistance in comparison to the full length *Oc-I* gene. The satisfactory resistance levels obtained with this transgene in the glasshouse resulted in successful field trials using potato plants expressing *Oc-IΔD86* under either the CaMV35S promoter (Urwin et al. 2003) or the ARSK1 promoter which is specifically expressed at the feeding site induced by cyst nematodes (Lilley et al. 2004). It is important to note that the expression of the *Oc-IΔD86* cystatin by potato plants in field trials has not demonstrated any substantial environmental risks to above ground organisms (Cowgill and Atkinson 2003; Cowgill et al. 2004) or perturbation of soil organism communities in the field (Cowgill et al. 2002), including non-target soil nematodes (Green et al. 2012).

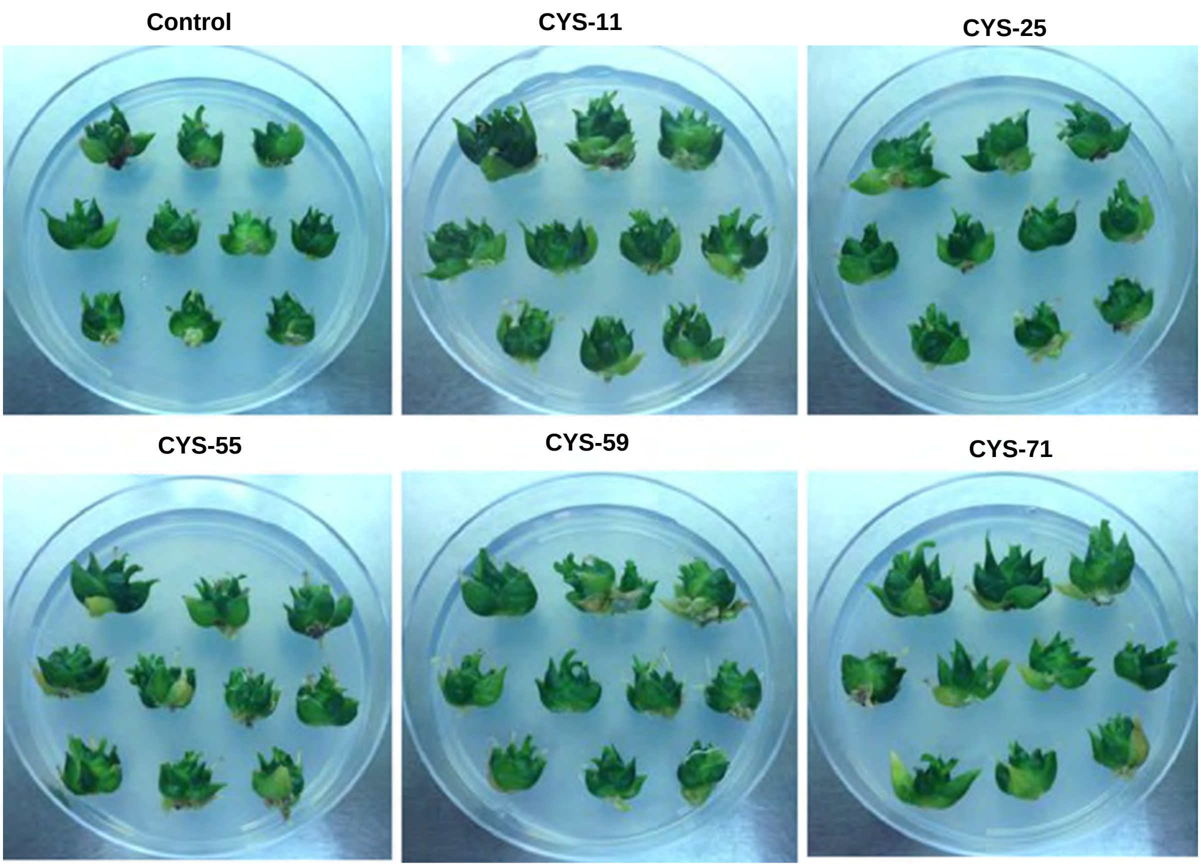

Fig. 3 Post-nematode infection bulb morphology of *Oc-IΔD86* overexpressing lilies compared to control. Plants overexpressing the *Oc-IΔD86* transgene showed better bulb growth and total mass (see Table 1) in comparison to wild-type lilies 2.5 months after nematode inoculation

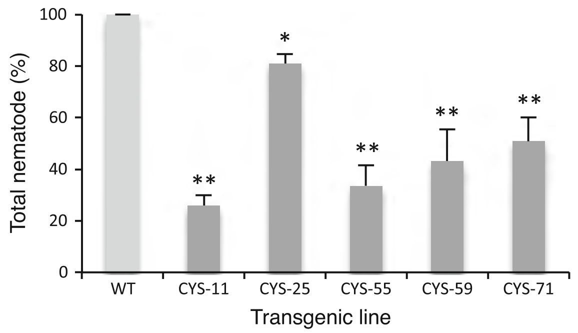

Fig. 4 Nematode challenge assays in *Oc-IΔD86*-overexpressing lily lines. Nematode infection tests of *Oc-IΔD86* overexpression lines (CYS-11, CYS-25, CYS-55, CYS-59 and CYS-71) compared with wild type (WT) lilies. Data shown represent the total mean nematode number ± SEM per gram fresh of root, from three independent biological assays, expressed as a percentage relative to the average total number for the control line. *Asterisks* indicate values significantly different from the wild type (*$P < 0.05$; **$P < 0.01$)

Our next goal was to validate the incorporation of such a transgene in lily plants. Root lesion nematodes are migratory nematodes that migrate into and feed on host cells, causing consequent root damage. Previous reports have shown that the CaMV 35S promoter is constitutively and highly expressed in lily transgenic roots (Kamo and Han 2008), making this promoter a suitable choice for testing our transgene. Although, we implemented three different bombardment pressures and a variety of plant materials cultured on three hormones, our transformation efficiencies were low, as in other reports. Transgenic lily plants resulting from bombardment of callus have been shown to have stable integration of the transgene, as demonstrated by inheritance of the transgene into seed-derived progeny (Kamo 2011). Expression of the *bar* and *uidA* transgenes were maintained in the progeny grown both in the greenhouse and outdoors (Kamo 2014).

Lilies are propagated by bulbs rather than seed, and the transgenic plants were confirmed to be non-chimeric by verification of the transgene in both shoots and roots in this study following 4 years of propagation by bulb scales and bulblet formation.

Our data from three independent nematode challenge assays using different bulb ages, indicate that the levels of resistance to the nematode are consistent. Four of five stable transgenic lily lines provided an estimated resistance to *P. penetrans* above 50 % in comparison to the nematode numbers in wild-type plants. The root lesion nematode life cycle can be up to 2 months and is dependent on environmental factors, including frequency of nematicide treatment and vigor of root growth (Mizukubo and Adachi 1997). In addition, the levels of root damage are frequently correlated with the population density in the field. Therefore, the reduction of the nematode density to certain threshold values could reduce the impact of RLN on the plants and increase the production yield. The action of Oc-IΔD86 has been associated with a strong reduction in nematode development and fecundity of females (e.g., Urwin et al. 1997). The continuous uptake of the protein might have delayed development of the nematodes through the lifecycle and also reduced their reproduction, which subsequently affected the number of individuals found associated with each lily transgenic line. Our data indicate that the resistance provided is not only reflected by fewer nematodes but by an increase in the root number, growth performance and biomass of each bulb. The improved performance of the transgenic plants may reflect not only their resistance to the nematodes but also a more general enhancement of vigor, particularly in response to stress. Cystatin overexpression has previously been observed to increase biomass and enhance chilling tolerance in transgenic tobacco plants (Van der Vyver et al. 2003). Two native cystatins overexpressed in *Arabidopsis* increased tolerance to high salt, drought, oxidative and cold stresses (Zhang et al. 2008).

The data we present show that expression of the *Oc-IΔD86* in lilies confers resistance to root lesion nematodes. These results suggest that this transgene may be an effective tool for improving resistance against nematodes in ornamental plants, thereby conveying a fundamental benefit to bulb and flower production. Although our results show good levels of resistance in monoxenic conditions, experimental trials are required in natural conditions to evaluate the effectiveness of this transgene in RLN-infested fields.

Acknowledgments This project was funded in part by the Fred C. Gloeckner Foundation and the California Department of Food and Agriculture 2012 Specialty Crop Block Grant awarded to Lee Riddle, Kathryn Kamo, and Rebecca Westerdahl. We thank Dr. Ben Matthews and Margaret McDonald (Soybean and Nematology Laboratory, USDA, Beltsville, MD) for the 'Williams 82' soybean seeds and for their helpful suggestions with the soybean hairy root system and Carol Masler (Nematology Laboratory, USDA, Beltsville, MD) for assisting with the nematode cultures. We thank Dr. Jonathan D. Eisenback for paper reviewing. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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Easter Lily Research Foundation

OF THE PACIFIC BULB GROWERS ASSOCIATION

"Quality Lilies Through Cooperative Research" VOL 37 NO 7 AUG 16 2012

2012 ELRF GREENHOUSE & BREEDING REPORT

BULBS DUG New Varieties 2010's dug Sept 1st
New Varieties 2009's & 2008's dug Sept 6-7
New Varieties 2003, 2004, 2005, 2006, & 2007 dug Sept 7-8
Seedlings dug Sept 20
Nellie White dug Oct 6

STORAGE in poly bags with semi moist peat at shed temperature until potting.

POTTING / ROOTING Oct. 13-14 in Premier HP (High Porosity) peat + perlite mix.
This mix has a lot of perlite for faster draining. Pots were put into greenhouse as potted to control heat & moisture. Average temperatures ran 63-65.
ROOTED Oct 14 ~ Oct 30 = 16 Days. Smaller bulbs, 5" to 8" size were potted in 0.58 Gallon (6") pots, Bulbs larger than 10" went into the taller 0.60-gallon sized pots.

COOLING at Hastings Tree Farm Cooler OCT 30 ~ Dec 11 = 42 days (1008 Hours)

GREENHOUSE BENCHED Dec 12 AM = DAY # 1 APRIL 5 "Greenhouse Day" = Day 115

GREENHOUSE TEMPERATURES

DATES	# of DAYS	3 Hour Dawn DIF	DAY	NIGHT
12/12 ~ 1/2	20	63-65	70	63-65
1/2 - 1/8	7	58	65	70-74
1/8 - 1/30	21	52	62-70	65-70
1/30 - 2/13	14	50	65-70	68-72
2/13 - 2/20	7	50	65-70	65-70
2/20 - 3/5	14	50	60-65	68-70
3/5 - 3/12	7	50	65-70	70-72
3/12 - 3/19	7	50	70	70-74
3/19 - 4/5	17	68	70	70-74

POT DENSITY Clones were @ 2.08 pots per square foot of bench, Seedlings were @ 1.82

HEIGHT CONTROL Morning shock temperature drop started Jan 1st (Day 20).
There was NO use of chemical growth regulators (PGR'S) in the greenhouse.

LOWER LEAF LOSS CONTROL No use of Promalin in greenhouse. Plants were allowed to lose lower leaves until brought into display room. Upon entering display room, the lower 1/2 of the plant leaves were sprayed with 125 PPM Promalin (Fascination).

Lower leaf loss is a clonal trait, Nellie White and certain other clones tend to lose lower leaves under the same environmental conditions that other varieties do not. Leaf mass does not seem to influence lower leaf loss as much as genetics, light level and root vigor. Clones that lost lower leaves even under good light situations are noted in the comments section of the data sheets.

CROP EMERGENCE NW emerged in 17~28 days, The range of all other plants was in the last days of rooting to + 42 days.

POT FUNGICIDE DRENCHES (rates in ounces per hundred gallons of water) (No Subdue)

DATE OF DRENCH	"BANROT" **SYSTEC** 8 OZ	**TERRAZOLE** 3.5 OZ	**TERRACLOR** 400 F 6 OZ	**BANOL** 6L 30 OZ	**FOSPHITE** 0.53 64 OZ	**CHIPCO** 2 F 6 OZ	**FERTILIZER**
10/14/2011	X	X	X	X	X	X	4 # Peters 15-0-15
12/13/2011	X	X		X	X	X	4 # Peters 15-0-15
1/12/2012	X	X		X	X	X	4 # Peters 15-0-15
2/15/2012	X	X		X	X	X	4# Peters 15-0-15
3/17/2012	X	X		X	X	X	

SHOW ROOM

Lily Seedlings began blooming on Day 84 = March 5th.
Day 84 in 2011, Day 91 in 2011, Day 93 in 2010, Day # 77 in 2009, Day 80 in 2008, Day 78 in 2007, Day 83 in 2006, Day 84 in 2005, Day 84 in 2004, Day 81 in 2003, & Day 82 in 2002).
Lily Clones began blooming on March 17 = Day 96
Plants were moved into the show room starting on March 23 = Day 102
Day 98 in 2011, Day 92 in 2010, Day 94 in 2009, Day 98 in 2008, Day 93 in 2007, Day 94 in 2006, Day 101 in 2005, Day 106 in 2004, Day 95 in 2003, Day 95 in 2002)
Plants were brought into the display room as they came into bloom. At this time they were sprayed with Promalin on the bottom half of the plant to preserve the foliage in the same condition they would have coming from the greenhouse. There was no temperature control in the show room, but temperatures remained mostly cool. The last display plants were moved in April 4 = Day 114
The earliest Clones displayed bloomed in an average of 104 days and the latest clones displayed averaged 115 days. Nellie White averaged 115 days (range 107 to 123 days)
Lighting in the display shed was provided 24 hours a day by overhead florescent fixtures.
27 different Clones of lilies, and 25 individual Seedlings were brought into the display.
Each clone was displayed in three bulb sizes. Bulb sizes ranged from 6.00” to 10.00 ”. Bud counts were generally above average this year with NW @ 0.97 buds per inch &
“98-40” @ 1.62 B/I

JUDGING

13 Judges were given scorecards to enter scores from 1 (very poor) to 10 (very good).
6 Judges marked that they were Bulb Growers, 4 Judges marked “Visitors”, 2 marked “Chem Reps”, 1 marked “Extension Agent”, and 1 was anonymous.

Plant information was given as follows: the bulb sizes of the three pots shown, the average number of buds per bulb inch from all five pots grown, the average blooming date of all five pots grown, and the average height.

Scores were computed for average score and standard deviation and Judges were given print outs of the total scores. Unlike most years, plants that had been blooming inside for several weeks still looked good and scored well. All plants were brought in as the first bud was puffy to just cracking. “Spring” was cool so the shed was cool constantly.

The average score was 5.89 .
There was pretty good agreement between Judges on scores with very rare exceptions.

Easter Lily Research Foundation
OF THE PACIFIC BULB GROWERS ASSOCIATION
"Quality Lilies Through Cooperative Research" VOL 38 NO 8 AUG 15 2013

2013 ELRF GREENHOUSE & BREEDING REPORT

BULBS DUG New Varieties 2011's dug Sept 12th
New Varieties 2010's dug Sept 13-19
New Varieties 2009, 2008, 2007, 2006, 2005, 2004, & 2003 dug Sept 20-24
2010 Seedlings dug Sept 24-25
2009 Seedlings dug Oct 1-4
Nellie White dug (Yearlings Sept 18) & Commercials Oct 11th

STORAGE in poly bags with semi moist peat at shed temperature until potting.

POTTING / ROOTING Oct. 16th in Premier HP (High Porosity) peat + perlite mix.
This mix has a lot of perlite for faster draining. Pots were put into greenhouse as potted to control heat & moisture. Average temperatures ran 63-65.
ROOTED Oct 17 ~ Oct 22 = 6 Days. Smaller bulbs, 5" to 8" size were potted in 0.58 Gallon (6") pots, Bulbs larger than 10" went into the taller 0.60-gallon sized pots.

COOLING at Hastings Tree Farm Cooler OCT 23 ~ Dec 2 = 41 days (984 Hours)

GREENHOUSE BENCHED Dec 3 AM = DAY # 1
MARCH 28th = "Greenhouse Day" = Day 116

GREENHOUSE TEMPERATURES

DATES	# of DAYS	3 Hour Dawn DIF	DAY	NIGHT
12/3~ 1/9	37	63-65	63-65	63-65
1/9-2/7	29	60	65	68
2/7-3/4	25	66-70	66-70	66-70
3/4-3/27	23	70-72	70-72	70-72
TOTAL	115			

HEIGHT CONTROL There was a slight 3 hour morning DIF of –5 to –8 degrees running from day 37 through day 66.
There was NO use of chemical growth regulators (PGR'S) in the greenhouse.

LOWER LEAF LOSS CONTROL No use of Promalin in greenhouse. Plants were allowed to lose lower leaves until brought into display room. Upon entering display room, the lower 1/2 of the plant leaves were sprayed with 125 PPM Promalin (Fascination).

Lower leaf loss is a clonal trait, Nellie White and certain other clones tend to lose lower leaves under the same environmental conditions that other varieties do not. Leaf mass does not seem to influence lower leaf loss as much as genetics, light level and root vigor. Clones that lost lower leaves even under good light situations are noted in the comments section of the data sheets.

CROP EMERGENCE NW emerged in 10~31 days, The range of all other plants was in the last days of rooting to + 40 days.

POT FUNGICIDE DRENCHES (rates in ounces per hundred gallons of water) (No Subdue)

DATE OF DRENCH	"BANROT" **SYSTEC** 8 OZ	**TERRAZOLE** 3.5 OZ	**TERRACLOR** 400 F 6 OZ	**BANOL** 6L 30 OZ	**FOSPHITE** 0.53 64 OZ	**CHIPCO** 2 F 6 OZ	**FERTILIZER**
10/19/2012							4 # Peters 15-0-15
12/5/2012							4 # Peters 15-0-15
1/4/2013							4 # Peters 15-0-15
2/4/2013							2# Peters 15-0-15
3/1/2013							0#

SHOW ROOM

Lily Seedlings began blooming on Day 71 = Feb 11th,
Day 84 in 2012, Day 84 in 2011, Day 91 in 2011, Day 93 in 2010, Day # 77 in 2009, Day 80 in 2008, Day 78 in 2007, Day 83 in 2006, Day 84 in 2005, Day 84 in 2004, Day 81 in 2003, & Day 82 in 2002). Lily Clones began blooming on Day 95 = March 7th.

Plants were moved into the show room starting on March 14th = Day 102
Day 102 in 2012, Day 98 in 2011, Day 92 in 2010, Day 94 in 2009, Day 98 in 2008, Day 93 in 2007, Day 94 in 2006, Day 101 in 2005, Day 106 in 2004, Day 95 in 2003, Day 95 in 2002)
Plants were brought into the display room as they came into bloom. At this time they were sprayed with Promalin on the bottom half of the plant to preserve the foliage in the same condition they would have coming from the greenhouse. There was no temperature control in the show room, but temperatures remained mostly cool.
The last display plants were moved on March 27th = Day 115
The earliest Clones displayed bloomed in an average of 100 days and the latest clones displayed averaged 129 days. Nellie White Yearlings averaged 114 days (range 110 to 118 days). NW Commercials were still “tipping down” at 110 days, suffered extreme root rot and were not displayed for judging.
Lighting in the display shed was provided 24 hours a day by overhead florescent fixtures.
24 different Clones of lilies, and 31 individual Seedlings were brought into the display.
Each clone was displayed in three bulb sizes. Bulb sizes ranged from 5.25” to 9.5 ”. Bud counts were generally slightly above average this year with NW @ 0.85 buds per inch.
Seedlings displayed ranged from 1.00 to 3.35 Buds per inch. Clones displayed varied from 0.73 to 1.45 buds per inch.

JUDGING

11 Judges were given scorecards to enter scores from 1 (very poor) to 10 (very good).
7 Judges marked that they were Field Bulb Growers of which 3 were also Greenhouse Growers, 2 Judges were identified as “Visitors”, 1 Judge was marked as a “Chemical Rep”, 1 Judge marked “Extension Agent”.

Plant information was given as follows: the bulb sizes of the three pots shown, the average number of buds per bulb inch from all five pots grown, the average blooming date of all five pots grown, and the average height.

Scores were computed for average score and standard deviation and Judges were given print outs of the total scores. Unlike most years, plants that had been blooming inside for several weeks still looked good and scored well. All plants were brought in as the first bud was puffy to just cracking. “Spring” was cool so the shed was cool constantly.

Judges scored from 1 through 10, The average score was 5.944 .
There was pretty good agreement between Judges on scores with very rare exceptions.

SCORE TALLY 2012 ELRF GREENHOUSE JUDGEING

CLONE I D	GROWER AVERAGE	SCORE Std Dev	POT #	CARD 1	CARD 2	CARD 3	CARD 4	CARD 5	CARD 6	CARD 7	CARD 8	CARD 9	CARD 10	CARD 11	CARD 12	CARD 13
09-14	4.154	1.951	1	3	8	6	5	4	6	3	6	4	2	3	1	3
10-7	6.154	1.676	2	6	4	7	4	8	6	5	7	7	9	8	5	4
08-21	6.077	1.441	3	7	5	8	5	6	7	5	9	5	4	6	7	5
07-6	6.923	2.253	4	8	5	9	4	9	10	8	7	7	7	9	3	4
08-25	5.308	1.182	5	5	5	5	5	4	8	6	6	5	4	7	5	4
97-15	5.615	1.895	6	5	3	6	4	7	8	2	8	6	5	6	8	5
10-8	6.538	1.664	7	5	4	6	6	8	7	9	8	8	8	7	4	5
10-14	5.538	2.145	8	7	3	6	3	6	7	4	9	7	8	6	2	4
05-9	6.769	1.691	9	8	8	5	6	5	9	6	10	8	6	7	5	5
08-26	6.231	2.006	10	8	3	6	6	5	10	6	9	6	3	7	6	6
07-8	7.231	1.739	11	9	8	3	7	9	8	8	8	9	6	7	7	5
05-12	7.154	1.625	12	7	8	4	6	8	8	10	9	7	6	7	8	5
04-8	5.692	1.251	13	6	7	5	4	6	6	5	9	5	5	6	5	5
08-2	6.231	2.088	14	7	9	2	7	7	6	8	9	6	5	7	3	5
N W	6.615	1.325	15	7	9	5	5	6	7	6	7	9	5	7	7	6
08-28	4.538	1.984	16	7	4	5	4	5	9	2	4	2	3	6	3	5
09-6	6.308	1.750	17	8	3	6	4	8	6	6	7	8	4	8	8	6
10-11	5.462	1.330	18	8	3	5	5	4	6	5	7	6	4	6	6	6
09-10	5.308	1.251	19	6	3	6	3	5	6	7	6	7	5	5	5	5
10-2	5.462	1.664	20	8	3	4	6	4	8	6	6	6	3	7	5	5
09-3	4.538	1.450	21	6	4	4	4	6	6	5	4	2	3	7	3	5
10-9	5.385	1.446	22	8	7	3	4	6	5	4	7	5	5	6	4	6
10-3	5.231	1.691	23	5	6	2	5	5	6	5	8	6	3	8	4	5
10-5	6.846	1.345	24	9	4	7	7	7	6	6	7	6	7	9	8	6
08-23	7.308	1.182	25	10	5	7	7	8	7	7	7	7	7	7	9	7
08-24	5.231	1.363	26	6	3	6	6	5	7	6	7	4	4	6	3	5
09-23 P	4.769	2.713	27	6	2	4	4	4	6	3	7	1	2	9	10	4
5-09-7.5	7.000	2.000	A	7	8	4	5	8	8	5	10	6	10	8		5
19-09-7.5	6.083	1.311	B	7	8	4	5	7	7	6	5	7	7	6		4
16-09-11 DNA	5.583	1.564	C	4	6	4	5	8	8	7	5	4	5	7		4
2-09-8	7.917	1.832	D	10	7	6	5	9	9	6	10	8	10	9		6
18-09-8.5 DN	6.333	0.888	E	7	7	6	5	7	7	5	6	6	6	8		6
26-08-9.5 A	6.167	1.337	F	7	8	6	4	6	6	7	6	7	4	8		5
31-09-9	6.500	1.446	G	6	6	8	5	7	8	6	8	5	5	9		5
26-08-10 A	6.333	1.826	H	8	7	7	4	7	8	8	6	2	7	7		5
33-08-10	4.750	1.485	I	5	5	4	4	5	7	5	4	3	3	8		4
31-09-7	5.083	1.379	J	5	5	7	4	6	7	4	5	4	3	7		4
32-08-9 A	6.000	1.414	K	6	8	5	4	6	8	6	6	6	4	8		5
16-09-9.5	6.417	1.929	L	6	6	4	7	7	9	9	5	6	3	9		6
20-09-8E-P	6.833	1.850	M	9	5	7	8	7	9	6	7	7	3	9		5
17-09-7.5	6.000	1.348	N	8	7	4	5	5	8	6	6	6	4	7		6
32-08-11	6.083	1.505	O	7	7	5	3	6	7	7	7	7	4	8		5
1-09-7.5	4.250	1.288	P	5	3	5	3	5	6	3	5	4	2	6		4
32-09-6.25	4.417	1.881	Q	4	9	2	4	5	5	4	5	3	2	6		4
26-08-11	6.417	1.730	R	6	7	6	6	7	10	9	5	5	5	7		4
24-09-8.25	4.917	1.929	S	6	4	8	6	5	7	4	4	2	2	7		4
32-08-10 C	6.417	1.165	T	7	8	7	8	6	7	7	6	4	6	6		5
26-08-10 C	6.583	1.311	U	7	7	6	9	5	6	8	6	8	5	7		5
27-09-7	5.250	2.261	V	5	3	7	9	7	7	5	3	5	1	7		4
29-09-8.25	5.833	1.749	W	5	8	5	8	6	8	4	4	6	4	8		4
23-09-9.25	5.417	2.151	X	5	4	6	9	6	8	6	3	5	1	7		5
4-09-9	5.500	2.067	Y	7	4	6	8	5	8	6	3	5	1	7		6
				F & G	F & G	E	F	C	F & G	V		F	V	V	V	G

2013 JUDGING FINAL SCORES SORTED

NEW CLONE	CLONE #	AVERAGE SCORE	SCORE Std Dev	POT #	FG CARD 1	FG/GG CARD 2	FG/GG CARD 3	EX CARD 4	FG CARD 5	FG CARD 6	VIS CARD 7	CR CARD 8	FG CARD 9	FG/GG CARD 10	VIS CARD 11
	FG=FIELD GROWER GG=GREENHOUSE GROWER EX=EXTENSION CR= CHEM REP VIS=VISITOR														
13-46	20-09-9.75 Pink	8.000	1.000	AA	8	6	8	8	7	9	8	8	8	8	10
13-7	10-10-9.25	7.818	1.079	R	9	9	7	7	7	7	8	9	8	6	9
13-24	21-10-10	7.727	1.272	X	6	7	8	8	9	10	8	7	6	7	9
	10-5	7.636	1.206	4	6	8	7	7	8	6	9	8	8	10	7
13-21	17-10-9 B	7.636	1.567	CC	8	8	9	5	6	8	5	9	8	9	9
	08-21	7.545	1.293	13	6	9	9	8	8	6	8	6	8	9	6
13-42	18-09-11 B	7.455	1.368	B	7	9	4	9	7	8	7	8	8	7	8
13-13	13-10-7 A ora	7.364	1.286	J	9	8	7	6	9	6	9	6	6	7	8
13-18	15-10-8 B	7.364	1.362	Z	6	8	7	9	10	6	6	8	8	6	7
13-2	3-10- 10.25	7.091	1.640	C	7	9	4	7	9	9	7	7	8	5	6
13-9	12-10-8.5 B	7.091	1.514	L	6	8	8	5	7	8	4	9	8	7	8
	10-2	7.000	1.483	12	6	9	5	8	7	8	6	6	8	9	5
13-26	25-10-10.75	7.000	1.732	I	5	6	7	6	9	5	8	10	8	8	5
13-15	15-10-9 A red	7.000	2.098	W	5	8	8	6	9	9	2	8	8	6	8
	09-38	6.909	1.640	19	5	7	8	6	3	7	8	8	8	8	8
13-1	3-10- 8 A	6.909	1.973	E	5	8	6	7	10	8	8	9	3	6	6
13-38	16-09-9.5	6.909	1.136	S	5	7	7	6	7	8	7	8	6	6	9
	10-7	6.727	1.191	3	5	8	7	6	7	7	7	9	6	7	5
13-25	23-10-10.5	6.636	1.859	U	7	8	3	7	7	8	3	8	8	7	7
	11-25	6.545	2.018	7	5	7	7	5	7	10	3	6	8	9	5
	08-23	6.455	1.572	20	4	7	6	8	5	8	4	6	8	7	8
13-10	13-10-8 red	6.455	1.864	H	7	5	3	8	8	4	7	6	6	8	9
13-40	16-09-11	6.364	2.063	Y	5	4	7	5	8	7	9	9	3	5	8
13-3	5-10-8	6.364	1.629	DD	6	6	6	5	7	8	3	9	6	6	8
13-19	15-10-8 C or	6.273	1.794	EE	6	5	8	6	5	6	5	8	3	8	9
13-47	27-09-10.75	6.182	1.537	K	5	7	5	5	8	7	7	8	3	6	7
13-16	15-10-9.25 A rd	6.091	2.212	F	6	6	3	6	4	6	7	10	3	7	9
13-8	10-10-10	6.091	1.868	BB	6	5	5	5	8	7	4	9	3	8	7
13-5	8-10- 8.5	6.000	1.612	D	8	7	5	6	7	7	2	6	6	5	7
	5-10-7.5	5.909	2.386	G	5	6	2	9	8	6	5	8	3	4	9
13-31	2-09-9.5	5.909	1.640	P	5	5	6	6	9	5	8	7	6	5	3
	10-6	5.818	1.888	5	4	7	2	5	7	9	5	7	6	7	5
	10-9	5.545	1.968	16	4	8	7	3	4	4	8	7	3	6	7
	27-09-10	5.545	2.115	T	4	6	5	8	8	6	8	7	3	4	2
	08-26	5.364	1.748	2	4	9	5	7	6	4	5	4	3	7	5
13-12	13-10-9.5 C	5.273	1.902	V	5	5	2	6	7	8	5	8	3	5	4
	N W Yrlg	5.182	0.874	24	5	5	6	5	4	5	5	7	6	5	4
	07-6	4.909	1.044	1	4	5	6	5	4	6	5	6	3	6	4
	04-8	4.909	1.640	22	4	2	4	7	5	7	4	6	3	6	6
	5-09-9 B	4.909	1.758	A	5	4	3	7	6	7	3	7	3	3	6
	07-8	4.818	1.601	6	4	4	3	7	6	7	3	6	3	4	6
	11-29	4.818	1.601	11	4	5	4	8	5	7	4	3	3	6	4
	10-8	4.818	1.250	15	4	4	5	5	3	5	5	6	3	7	6
	08-28	4.818	1.079	21	4	3	4	7	4	5	5	5	6	5	5
	6-10-7.5	4.818	1.722	M	4	4	7	5	6	4	6	8	3	3	3
	11-30	4.636	1.690	10	4	3	2	4	7	6	4	5	6	7	3
	10-14	4.636	1.206	17	4	5	6	5	3	4	4	5	3	7	5
13-44	20-09-8.75 B pink	4.636	2.014	N	4	4	3	7	3	6	4	8	3	2	7
	11-26	4.545	1.036	14	4	6	4	5	5	5	5	4	3	6	3
	11-28	4.455	1.572	9	4	4	4	4	4	5	3	5	6	8	2
	05-14	4.364	1.748	23	4	2	3	6	2	4	5	6	6	7	3
13-28	31-10-9 B pink	4.364	1.690	O	5	4	3	4	1	6	5	7	3	4	6
	09-6	3.909	1.514	18	4	3	5	3	1	4	6	6	3	5	3
13-36	10-09-9 A pink	3.727	1.489	Q	4	2	2	5	3	4	5	7	3	3	3
	05-9	3.636	1.027	8	4	3	4	3	3	5	3	5	3	5	2
				AVER	5.20	5.94	5.24	6.07	6.11	6.44	5.54	7.04	5.17	6.22	5.98

FIELD TRAITS 2013 HARVEST NOTES

POT #	CLONE #	SIZES FORCED	PARENTS FEMALE	PARENTS MALE	YEARLING	SCALE	STEM BBT	FOLIAGE	SPROUT	BASE ROOTS	STEM ROOT	OTHER	
1	05-9	FORCE 6.5-8.5	98-40	99-9	TEARDROP	LOTS MD-LG	ALMOST NONE	95% DEAD	NONE	VERY GOOD	GOOD		
2	12-15	FORCE 5 5.5-8	09-38	07-9	BIG FIRM ANGULAR BLOCKY PEAKED FORCE SCALETS & YEARLINGS	XCLT MANY UP TO 5" SIZE	LOTS OF LG	NO BOTRYTIS DARK GRN THICK WIDE	2 / 14	GOOD	XCLT	FORCE SCALETS & YEARLINGS 6 DNs IN BIGGEST BULBS DNS IN YEARLGS	
3	08-26	FORCE 7-9	04-4	01-25	TALL FIRM WHITE	GOOD # SM-LG	GOOD # SM-LG	20% DEAD	2 OF 40	XCLT PLUS	XCLT		GOOD FIELD
4	08-23	FORCE 7-9	98-37	05-12	POINTY TEARDROP	LOTS MD-LG	LOTS LG	70% DEAD	NONE	POOR TO VERY GOOD	GOOD	NEMAS	BOTRYTIS & SPROUTS
5	97-28	FORCE 6.5-8.5	89-1	91-18	VERY TALL GOOD SIZE	LOTS SM-LG	OK # SM-LG	DARK UPRIGHT 10% BOTRYTIS	NONE	XCLT	VERY GOOD		BIG BULB NICE PLANT
6	07-6	FORCE 6.5-8.5	04-8	04-5	BIG YEARLINGS ON SMALL TOPS OK COMS	OK # SM-LG	LOTS SM-LG	30% DEAD WIDE RIBBED COMPACT ARCH	NONE	XCLT	XCLT	6.5 to 7.5" YEARLINGS	
7	12-35	FORCE 5 5.5-7.5	04-8	07-9	BLOCKY FIRM BIG SCALES	XCLT SIZE & #	MANY SM-LG	DK GRN WIDE THICK RIBBED	NONE	VERY GOOD	GOOD	NO BOTRYTIS	
8	12-4	FORCE 5 6.5 -8	09-14	07-9	WHITE FIRM SEMI TEARDROP SNs CROFT SPOTS	MANY SM-MD	SM-LG MANY	UPWARD RIBBED BO BOTRYTIS	NONE	VERY GOOD TO XCLT	OK	NO BOTRYTIS BETTER THAN 12-3	
9	08-21	FORCE 6.5-8.5	99-9	01-25	ROUND FIRM	OK # MD -LG	VERY FEW	90% DEAD	NONE	VERY GOOD	VERY GOOD		DARK GOOD FIELD BOTRYTIS
10	11-10	FORCE 6.5-8.5	08-13	06-22	HIGH CROWNED BIG ON SMALL TOPS FIRM SN	FEW SM-LG	VERY FEW SMALL	LONG THIN	SHALLOW NONE	VERY GOOD	GOOD	60% BOTRYTIS	BIG PINK FLW NICE PLANT LESS PURPLE BLOCKY BULBS
11	12-18	FORCE 5 5.5-7.5	07-16 T	07-10	BIG ROUND CLASPED FIRM BALLS	MANY VERY LARGE	SOME MD-LG	WIDE THICK LONG DARK UPARCH	2 / 7 UNDER GROUND	VERY GOOD	XCLT	FLW STEM FIRE ONLY 2 DNs	
12	10-9	FORCE 6.5-8.5	03-9	03-17	BIG SQUAT ROUND	MANY SM-LG	LOTS SM-LG	NO BOTRYTIS LONG OUTWARD	NONE	GOOD	GOOD	SOME DNS	XCLT FIELD SOME BOTRYTIS
13	12-36	FORCE 5 6-8	04-8	07-9	BLOCKY ANGULAR FIRM SN	GOOD SIZE& #	OK # SM - MED	LT GRN NW TYPE	NONE	GOOD	GOOD	SOME BOTRYTIS DNS ON VERY LG BULBS	
14	12-16	FORCE 5 5.5 ~ 7.5	09-38	07-9	HUGE TALL FIRM LONG SCALES DNs ON BIG FORCE SCALES & YEARLINGS	LOTS LARGE XCLT	FEW BIG	XCLT THICK WIDE DARK GRN	1 / 11	GOOD	FAIR	FORCE SCALETS & YEARLINGS 3 DNS in LG V LITTLE BOTRYTIS	
15	08-28	FORCE 6.5-8.5	01-25	04-8	SMALL SIZE TALL POINTY	LOTS SM-MD	VERY FEW SM	70 % DEAD	NONE	VERY GOOD	OK		
16	07-3	FORCE 6.5-8.5	04-6	04-8	GOOD SIZE TALL HARD	GOOD # SM-MD	LOTS SM-MD	60% DEAD COMPACT OUTUPWARD	NONE	VERY GOOD	OK		STACKED PRIMARYS
17	12-32	FORCE 5 5.5-7.5	05-9	07-9	SQUAT FIRM SOME DNs	OK # SIZE	LOTS BIG	SHORT WIDE FAT RIBBED	1 OF 8	VERY GOOD	VERY GOOD	VERY LITTLE BOTRYTIS	
18	11-21	FORCE 5 6.5-8.5	08-21	08-1	XCLT VERY HARD HEAVY FIRM ROUND SN	XCLT BIG	LOTS	UPRIGHT RIBBED	SHALLOW NONE	VERY GOOD	XCLT		EXCELLENT FIELD DARK PRIMARY GOOD FIELD VHBC
19	11-25	FORCE 5.5-8.5	08-21	05-9	TALL ROUND TEARDROP	FEW MED	LOTS SM-MED	COMPACT ARCHING	NONE	XCLT	OK	NO BOTRYTIS	GOOD SCORES SMALL, BIG FLWS A FEW SPTS
20	11-33	FORCE 6-8	05-9	07-10	ROUND HARD	FEW SM-MED	FEW SM	COMPACT UPARCH	NONE	POOR TO GOOD	GOOD	LITTLE BOTRYTIS NEMAS POOR PROP	SHORT HBC
21	12-42	FORCE 5 6.5-8.5	08-24	08-20	BLOCKY FIRM SNs	LOTS SM-LG	LOTS VERY BIG	DARK UPARCH	NONE	GOOD	VERY GOOD	BOTRYTIS	
22	04-8	FORCE 6.5-8.5	96-29	N W	HUSK TALL	GOOD # SM-LG	LOTS SM-MD	100% DEAD	NONE	OK TO V GOOD	OK		BIG BULBLET NO SPROUTS
23	11-22	FORCE 5 6-8	08-21	08-2	FIRM ROUND LOTS OF DNs	FEW BUT VERY LG	OK	VERY GRN UPRIGHT RIBBED	SHALLOW NONE	XCLT	XCLT	NO BOTRYTIS	BIG STUFF IN FIELD SWORD LEAVES VHBC
24	12-40	FORCE 5 6.5-8.5	08-21	04-8	OK SIZE SQUAT ROUND SNs	LOTS OF SM-LG	LOTS SM=LG	BROAD THICK RIBBED ARCHING	NONE	GOOD	VERY GOOD	LOTS BOTRYTIS	
25	09-38	FORCE 6.5-8.0	05-3	05-7	VERY LARGE FIRM WHITE BOXY	GOOD # MED - LG	NONE	NO BOTRYTIS THICK FAT DARK ARCHING	NONE	VERY GOOD	XCLT	VERY BIG BULBS BOTRYTIS RESISTANT	FORCE COMS FROM BBTS HIGH SCORES XCLT PROP
26	11-34	FORCE 7-9	05-9	07-10	ROUND SOME CROFT SPOTS	FEW SM-MED	NONE	90% BOTRYTIS NARROW UPARCH	NONE	POOR TO GOOD	POOR TO OK	SOME DNS POOR PROP	OK
27	05-12 T	FORCE 6.5-8.5	98-40	N W	HIGH CROWN TALL LOOSE	GOOD # MD-LG	ALMOST NONE	BIG LVS BOTTOM 1/2 DEAD 40% BOTRYTIS	NONE	OK-VERY GOOD	OK-V GOOD		BAD SPROUTS BOTRYTIS NICE DARK PLANT
28	10-8	FORCE 6.5-8.5	03-9	03-17	HUGH TALL BOXY FIRM WHITE	GOOD # SM-LG	LOTS MD-LG	NO BOTRYTIS LONG OUTWARD	NONE	VERY GOOD	GOOD	LOTS OF DNS	XCLT FIELD SOME BOTRYTIS
29	03-21	FORCE 6.5-8.5	00-15	99 PM	YRLGS TALL COMS SQUAT	FEW	FEW SM	75% DEAD	NONE	OK TO V GOOD	GOOD		NICE IN FIELD
30	11-8	FORCE 5 6.5-8.5	08-13	06-22	HIGH CROWNED TALL BOXY SN FIRM WHITE	OK # GOOD SIZE	FEW MD	WIDE VERY GRN RIBBED UPRIGHT	SHALLOW NONE	VERY GOOD	VERY GOOD	NO BOTRYTIS	VERY NICE 1.06 B/I BIG PINK LONG BLUSH PRIMARY FLW
31	11-30	FORCE 6.5-8.5	08-26	08-1	CHUNKY HARD BLOCKY FIRM	FEW SM-LG	VERY FEW	WIDE THICK	NONE	XCLT	VERY GOOD	VERY LITTLE BOTRYTIS	NO SPTS NICE BROAD DARK, TERTS on lg
32	12-34	FORCE 5 6-8	05-14 T	06-18	FIRM WHITE	LOTS of BIG	FEW BIG	THICK WIDE RIBBED	NONE	GOOD	VERY GOOD	STEM FIRE	
33	11-38	FORCE 8-9	05-3	05-9	BLOCKY THICK WHITE SCALES	FEW SM-LG	FEW SM	COMPACT BROAD	NONE	POOR TO V GOOD	POOR TO OK	40% BOTRYTIS SMALL 7-8 " COMS	TOP SCORE LBC 0.87 GOOD FIELD PRIMARY FLW
34	N W	FORCE 7.25 ~ 10			OK SIZE	OK # GOOD SIZE	FEW SM - MD	100% DEAD	NONE	POOR TO GOOD	POOR TO OK	SOME DNS POOR BBT PROP	

2015 GREENHOUSE JUDGING SCORES

		JUDGES	NAME	ANDREA								LEE
GROWER AVERAGE	SCORE Std Dev	CLONE #	POT #	CARD 1	CARD 2	CARD 3	CARD 4	CARD 5	CARD 6	CARD 7	CARD 8	CARD 9
8.222	1.202	12-41	6	9	8	8	10	6	9	9	7	8
8.000	2.000	12-15	8	3	8	10	9	8	8	9	8	9
8.000	1.118	2-12-7	B	8	7	9	9	8	6	7	9	9
7.778	1.481	12-35	10	8	5	8	9	9	9	7	6	9
7.556	2.128	12-16	5	6	4	10	5	9	8	8	8	10
7.556	1.014	12-38	11	8	7	9	9	8	7	7	6	7
7.444	1.424	12-40	16	7	6	9	5	8	9	9	7	7
7.444	1.333	21-12-9b	Q	8	6	7	9	5	8	9	7	8
7.222	2.108	21-12-10	F	9	6	10	7	7	3	9	6	8
7.111	1.453	20-11-9 C	D	10	6	7	5	6	8	7	7	8
7.111	0.782	19-12-9	E	6	6	8	7	7	8	8	7	7
7.111	1.616	21-11-7.25	M	5	7	7	8	5	10	8	8	6
7.111	1.269	26-11- 8.5 B	AA	8	8	6	7	6	8	7	9	5
7.000	1.118	12-32	15	6	6	6	8	7	8	9	6	7
7.000	0.866	24 - 11- 8.25	BB	8	6	6	7	6	8	7	8	7
6.889	1.453	12-44	22	7	6	6	5	7	7	10	8	6
6.889	1.691	1-12-7.75	H	10	7	5	6	7	9	5	7	6
6.778	1.563	19-12-7.25	C	6	6	9	5	6	5	8	9	7
6.778	1.716	2-12-9.25	L	9	6	5	7	6	8	9	7	4
6.667	1.414	12-4	12	6	6	8	9	6	8	5	5	7
6.556	1.236	26-11-8.5a	P	7	7	6	9	5	6	7	7	5
6.444	1.878	11-25	7	6	5	10	8	5	8	6	4	6
6.444	2.297	12-26	20	9	6	3	8	4	4	9	8	7
6.444	1.014	12-45	21	6	5	7	6	5	8	7	7	7
6.444	1.810	14-11-9.75	A	9	7	5	4	7	6	8	4	8
6.444	0.882	10-12-8	T	8	6	5	6	6	6	7	7	7
6.333	1.225	6-11-10	O	6	6	5	8	7	5	8	5	7
6.222	1.202	8-11- 8 B	CC	7	5	4	6	8	6	7	7	6
6.111	1.691	12-12	9	7	5	3	7	8	5	7	5	8
6.111	2.205	12-31	14	3	6	5	5	8	6	10	4	8
6.111	1.537	8-11-9	W	6	5	4	7	8	4	8	7	6
6.000	1.732	6-12-7 pink	U	8	7	4	8	7	3	6	6	5
5.889	0.928	12-33	3	6	6	7	6	7	4	5	6	6
5.889	1.691	1-12-8.5	X	4	6	5	7	8	3	6	8	6
5.778	1.716	11-33	2	8	6	6	5	7	4	8	3	5
5.778	1.563	12-28	4	7	4	4	6	8	4	7	5	7
5.778	0.972	9-12-9.5 b	K	4	6	7	7	5	6	6	6	5
5.667	1.500	4-12-11	I	3	5	8	6	6	4	6	6	7
5.667	1.414	5-11-11.25	J	5	6	6	6	5	5	8	3	7
5.556	1.014	1-12-7.25	Y	5	7	5	5	4	6	6	5	7
5.556	0.882	20-11-8b	Z	7	6	4	6	5	5	5	6	6
5.444	1.130	12-14	1	7	7	5	5	6	4	5	4	6
5.444	2.242	12-27	18	8	4	2	6	4	3	7	7	8
5.444	0.882	N.W.	27	7	5	4	6	5	5	6	6	5
5.333	1.871	11-38	19	6	6	4	6	7	3	2	7	7
5.222	1.787	12-10	13	7	5	2	7	7	3	5	6	5
5.222	1.563	11-21	23	3	5	7	6	6	6	7	3	4
5.222	1.922	27-12-7 pink	S	8	5	2	7	3	5	5	7	5
5.222	2.108	2-11-8 pink	V	6	5	2	8	3	3	7	6	7
5.111	1.833	07-3	25	5	5	8	4	5	3	8	5	3
5.111	1.364	07-15	26	5	5	4	5	5	5	6	8	3
5.000	2.236	28-12-7.5c pink	N	7	5	1	8	3	4	6	4	7
4.556	1.236	09-38	24	5	4	5	4	5	5	7	3	3
4.222	1.202	5-12- 8 pink	G	6	5	3	5	3	3	5	3	5
4.000	1.658	26-11-9.25	R	5	5	5	4	3	5	1	2	6
2.889	1.054	11-30	17	3	4	2	3	4	2	4	1	3
			AVER	6.5357	5.7857	5.750	6.5357	6.0536	5.7321	6.875	6.000	6.3929

2012 GREENHOUSE SELECTIONS

12-1 7.917 pts

12-2 5.500 pts

12-3 7.000 pts

12-5

12-6

12-7

12-8

12-9

12-10

12-11

12-12

12-13

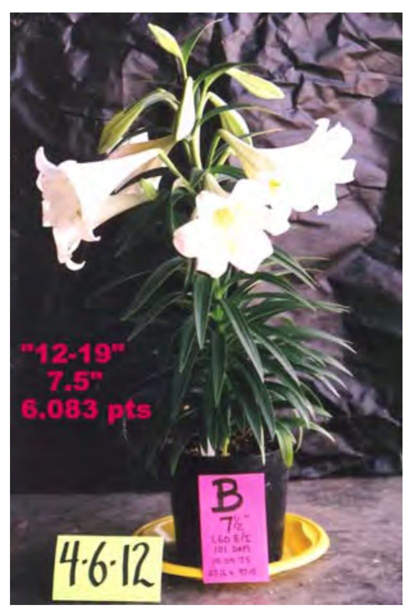
12-14

12-15 6.417 pts

12-16 5.583 pts

12-17 6.000 pts

12-18 6.333 pts



12-19 6.083 pts

12-20

12-21

12-22

12-23

12-24

12-25

12-26

12-27 "M" 6.833 pts

12-28

12-28 B

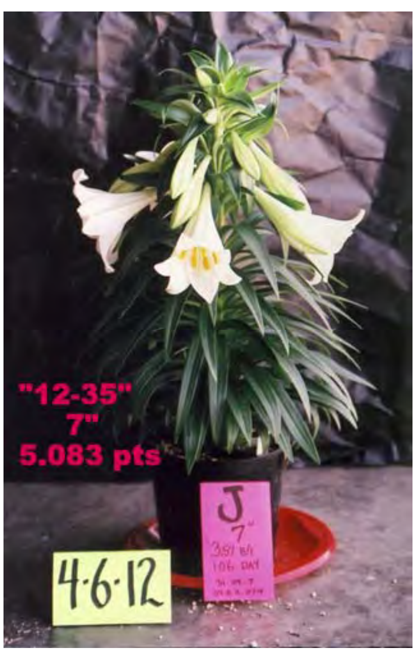
12-30

12-31

12-32

12-33 5.250 pts

12-34 5.833 pts



12-35

12-36

12-37

12-38

12-39

12-40

12-41

12-43

12-44

12-45

12-46

2013 NEW GREENHOUSE SELECTIONS

8” 102 Day 2.00 B/I HS

10.25” 101 Day 1.75 B/I HS

8” 114 Day 1.75 B/I

9” 101 Day 1.33 B/I

8.5” 101 Day 1.33 B/I

9.5” 92 Day 1.55 B/I

9.25” 102 Day 1.18 B/I V VHS

10” 114 Day 1.80 B/I

8.5” 100 Day 1.88 B/I HS

2013 NEW GREENHOUSE SELECTIONS

8" 102 Day 1.12 B/I

8.25" 103 Day 0.96 B/I

9.5" 107 Day 2.00 B/I

7" 102 Day 1.85 B/I HS

8" 97 Day 1.36 B/I

9" 109 Day 1.11 B/I HS

9.25" 105 Day 3.35 B/I

8" 110 Day 1.00 B/I HS

8" 113 Day 2.00 B/I

2013 NEW GREENHOUSE SELECTIONS

12" 119 Day 2.08 B/I

9" 114 Day 2.00 B/I VHS

9.5" 110 Day 1.68 B/I

8.5" 115 DAY 2.23 B/I

10" 106 Day 1.00 B/I V VHS

10.5" 106 Day 1.61 B/I

10.75" 101 Day 1.67 B/I HS

7.5" 116 Day 2.00 B/I

9" 101 Day 1.44 B/I

9" 102 Day 1.88 B

2013 NEW GREENHOUSE SELECTIONS

9.75” 91 Day 1.64 B/I

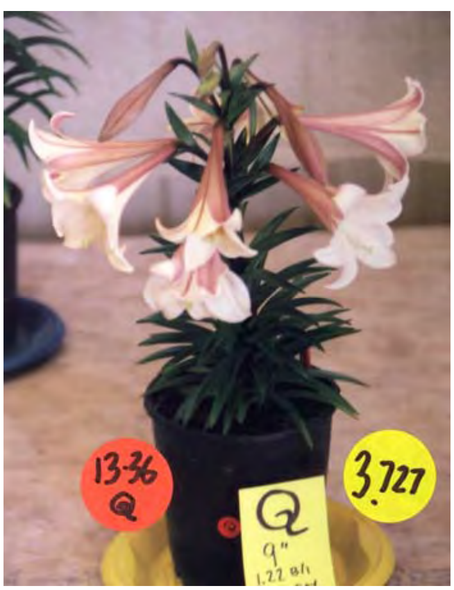
9.5” 104 Day 1.15 B/I

10.25” 99 Day 1.85 B/I

7.5” 115 Day 1.46 B/I

9.5” 87 Day 1.36 B/I

9” 114 Day 0.88 B/I



9” 105 Day 1.22 B/I

11” 111 Day 1.36 B/I

9.5” 107 Day 2.10 B/I HS

2013 NEW GREENHOUSE SELECTIONS

10.25” 99 Day 1.46 B/I

11” 109 Day 2.09 B/I HS

10.25” 99 Day 2.14 B/I

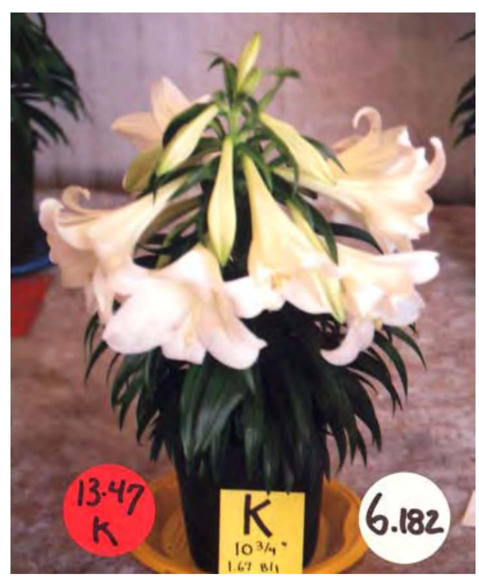
11” 102 Day 1.36 B/I VHS

8” 92 Day 1.25 B/I

8.75” 101 Day 1.14 B/I

9.5” 99 Day 1.89 B/I

9.75” 110 Day 1.23 B/I TOP SCORE



10.75” 101 Day 1.67 B/I

LILY SHOW MARCH 28 2013

CLONES 1 ~ 15

CLONES 16 ~ 24 & SEEDLINGS “A” ~ “J”

SEEDLINGS “G” ~ “EE”

NW COM 8.5” & 7.25”   NW YRLG 8 & 8 5.182

11-2 8.25”

11-25 7.75” 6.545

11-28 5.5” & 8.25” 4.455

11-29 5.5” 4.818

11-30 8.75” 4.636

11-33 8.25”

10-2 7" 7.000

10-5 9.5" 7.636

10-6 8.75" 5.818

10-7 9" 6.727

10-8 6.5" 4.818

08-21 7" 7.545

08-23 7" 6.455

08-28 6.5" 4.818

07-8 6.25" 4.818

05-9 7.25" 3.636

04-8 7" 4.909


10·8
7½

10·9
7½

10·10
6½

10·19
7½

09·21
7½

11·1
7¼

11·4
8"

11·30
8¾

08·23
7"


13.46
AA
8.000
Top

ELRF GREENHOUSE PHOTOS 2014

SCORE CLONE & SIZE POT #

12-4 6.75"

12-10 8.5"

12-13 10.5"

12-15 5.5"

12-18 6"

12-26 7.75"

12-28 10.75"

12-32 7.25"

12-34 7"

12-36 6.5"

12-40 7.5"

12-42 6.75"

11-6 7"

11-8 7"

11-10 6.5"

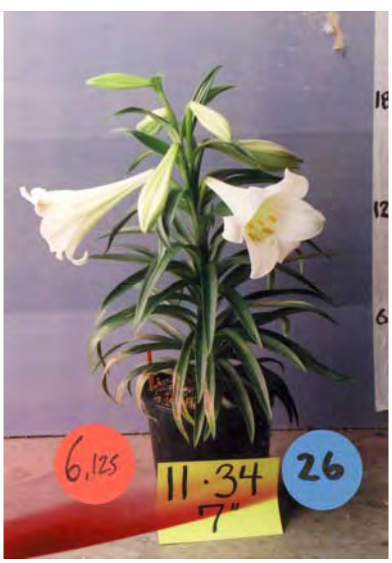
11-21 7"

11-22 7"

11-25 7.5"

11-30 7"

11-33 6.75"

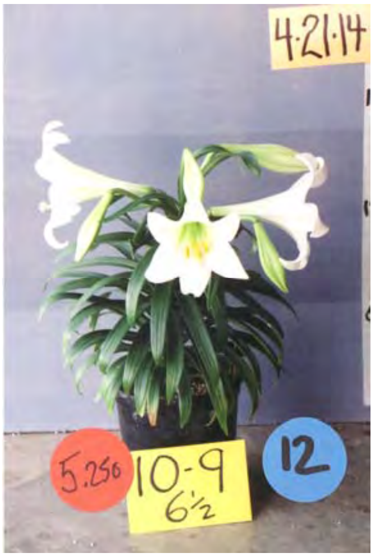


11-34 7"

11-38 7.25"

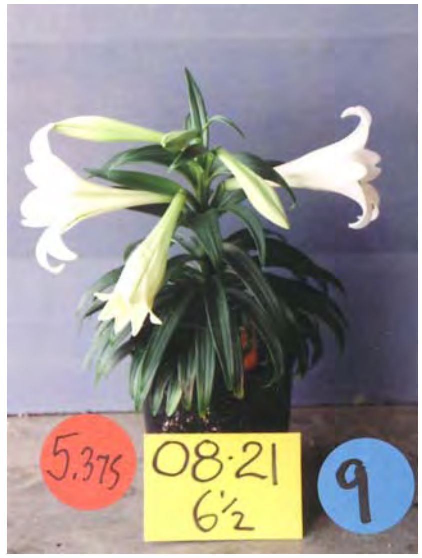
10-5 8"

10-8 7.75



10-9 6.5”

09-38   7.5”



08-21   6.5”

08-23   7”

08-26   8”

08-28 6.5”

07-3   7.25”

07 –6   6.5”

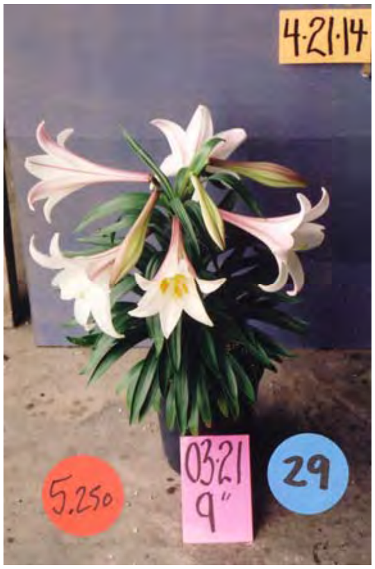
05-9 7”

05-12 6.75”

04-8 7”

03-4 8.5”

03-17 7”



03-21 9”

97-28 7”

N W 8”

CLONES # 1 to # 17

CLONES # 18 to # 34

SEEDLINGS A to AA

ELRF SEEDLINGS ~ 2014 SELECTIONS

14- 1 6.5”

14-2 8.5’

14-3 7.25”

14-4 **G** 7”

14-5 6.5”

14-6 8.75”

14-7 8.25”

14-7 **F** 8.25”

14-8 **A** 8.75”

14-9 **C** 9.25”

14-10 **J** 7.25”

14-11 **B** 7.5”

14-12 **K** 9"

14-13 **W** 7.75"

14-14 **T** 8"

14-16 8"

14-17 7"

14-18 **P** 7.5"

14-19 7.25"

14-20 **Z** 7.5"

14-20 **Z** 7.5"

14-21 7.5"

14-22 7.5"

14-23 **L** 8.5"

14-24 **U** 9.5"

14-25 **Q** 6.5"

14-26 7.75"

14-27 **V** 7"

14-28 **O** 8"

14-29 **A A** 9.25"

14-30 **Y** 9.25"

14-31 9.25"

14-32 **S** 9.75"

14-33 **H** 8.75"

14-34 10.5"

14-35 9.5"

14-37 **E** 11.5”

14-38 **R** 9.5”

14-39 9”

14-40 **I** 10.25”

14-41 **X** 11.5”

14-42 7.75”

GREENHOUSE 2015 PHOTOS

12-4 ~ 7"

12-5 ~ 8"

12-10 ~ 8"

12-12 ~ 7.5"

12-14 ~ 6.25"

12-15 5.5"

12-15 6"

12-15 7"

12-16 5.5"

12-16 6.5"

12-16 7.5"

12-16 8.25"

12-26 7"

12-27 7"

12-28 6.5"

12-31 7"

12-32 7”

12- 33 7”

12-35 7”

12-35 8”

12-38 9”

12-40 7.25”

12-41 7”

12-41 8.5”

12-44 7.25”

12-45 8”

11-21 6.75”

11-25 7”

11-30 6”

11-33 6.25”

11-38 7”

09-38 6.5”

07-3 6”

07-15 7.5”

N.W. 9.5”

SEEDLINGS & 2015 SELECTIONS

1-15 7.75” 2-15 8.5” 3-15 8.75” 4-15 9”

5-15 7” 6-15 9.25” 7-15 11” 8-15 6”

9-15 7” 10-15 7” 11-15 8” 12-15 7.25”

13-15 9” 14-15 10” 16-15 10” 17-15 6.5”

18 –15 7”

19-15 6”

20-15 7”

21-15 7”

22-15 7.5”

23-15 8”

24-15 6.75”

25-15 6.75”

26-15 6.25”

27-15 8”

28-15 10”

29-15 8.5”

30-15 8”

31-15 9”

32-15 7.75”

33-15 9.5”

34-15 10.25”

35-15 7.5”

37-15 9.25”

38-15 9.75”

39-15 10.25”

40-15 9.5”

41-15 9.5”

42-15 8”

43-15 9”

44-15 7.25”

45-15 9.25”

47-15 8.25”

48-15 8.5”

49-15 8.5”

50-15 8.25”

51-15 7.75”


2015 SEED PRODUCTION


2015 SEED PRODUCTION


2015 SEED PRODUCTION

Easter Lily Research Foundation

OF THE PACIFIC BULB GROWERS ASSOCIATION

"Quality Lilies Through Cooperative Research"

VOL 39 NO 3 APRIL 29 2015

2015 ELRF GREENHOUSE FORCING REPORT

SEPTEMBER 2014~ APRIL 2015

Digging, Potting, Drenching, Forcing Schedule

Clone Forcing Growth Data

Seedling Forcing Growth Data

LILY JUDGING SHOW

Results of Lily Judging

Photos of Lilies in Bloom at Lily Judging Show

GREENHOUSE JUDGING SCORES 2011 to 2015

NEW 2015 VARIETIES

Greenhouse growth Data on 51 new varieties

PHOTOS OF 51 NEW VARIETIES

Multiple Season FIELD GROWTH DATA of 27 CLONES

GREENHOUSE TEMPERATURES

START	STOP	# of DAYS	DAY	NIGHT	3 HR AM DIF	- DIF
DEC 4	JAN 6	34	60~66	60~66	60~66	0
JAN 7	JAN 19	12	65~68	65~68	58	- 8.5
JAN 20	FEB 10	22	62~66	62~66	58	- 6.0
FEB 11	FEB 16	5	68~76	68~76	65	- 7.0
FEB 17	MAR 14	26	64~72	64~72	55	- 13.0
MAR 15	MAR 26	10	64~70	64~70	56	-12.0

Easter Lily Research Foundation

OF THE PACIFIC BULB GROWERS ASSOCIATION
"Quality Lilies Through Cooperative Research"

DESIGN PROTOCOLS: Nematode Resistant Easter Lily Field Trial (App # 436422)

Performance Standard 1: Shipping and maintenance at destination:
In May 2014, sterile plants of Easter lilies were shipped from USDA Beltsville by FedEx directly to Lee Riddle, manager of the Easter Lily Foundation in Brookings, Oregon 97415 15636 Highway 101 South; Tel: 541-469-2215; email: easterlilyresearch@gmail.com).
USDA Beltsville shipped a total of 240 jars of lilies (40 jars/plant line). They were marked as follows:
(1) Non-transformed line: Nellie White (NW)
(5) Transgenic lines: Cys-11, Cys-25, Cys-55, Cys-59, Cys-71
The first test plot location was planted May 2014, 30 feet in front of the ELRF office door & desk window allowing visual oversight of test plot during working hours. The second test plot location is +/- 600 feet from the office window in the 2015 planting field. The ELRF research station is fully fenced and the gate is locked when staff are not present. There is a 1000 foot private road from the gate to the research office / test site. There is no public access. Fenced, gated farm fields producing cattle, hydrangeas, hay, & lilies surround the station.

Performance Standard 2: Inadvertent mixing of material in environmental release
The current trial plants the bulbs into field soil. The trial area has moved up to the edge of our current planting field about 600 feet from, and visible from the office window. Plot lengths are 5 feet in length. The numbers of plants per plot ranges from 3 to 9 bulbs depending on the variety. There are a total of 72 plots (6 varieties X 4 treatments X 3 replicates =72).
The planting area is separated from other lilies by at least one row (see excel map). Each plot within the trial is separated from the adjacent plot by 4 feet of bare soil. We further identified each converted & unconverted lily type by both variety specific color-coded flag and unique plot number stakes marking each plot. At harvest we will hand dig into pre-labeled containers and move them into the locked office / grading room.

Flower stalks will be removed before flowers are blooming to prevent release of pollen. Easter lilies are self-sterile, cannot self-pollinate, nor do they cross pollinate naturally with other lilies. They will be stored in the locked office in the event that a third year field study is applied for or autoclaved if not used next year. After the field trial, the volunteer monitoring area will be visually checked for 12 months, every 3 months to determine if any bulbs were lost from the containers and germinate. Any unusual occurrences during this field study and following time period will be reported to APHIS.

The planting shall be mapped. Refer to attachment map (excel file) for test site area marked in green. Test plots shall be located on the field edge at least one row away from other field planted lilies. Adjacent plots are harvested by a combination of hand and single row equipment and will be harvested before the test plots. Test plots will be harvested by hand digging plots individually into containers marked with the plot number. Containers are then moved into a secure grading room where they will be graded & stored.
This is not a food or feed crop and will not enter the marketplace.

Performance Standard 3 : Identity of Regulated materials
Plants will be kept in individual field plots marked with field labels and mapped for location, see Excel map attached. At harvest (October 2015) the field harvest containers will be

brought into the office/ bulb shed facility where the bulbs can be removed from the containers. Dr. Becky Westerdahl, Nematologist at UC Davis, will analyze root samples obtained from test bulbs on site, in the Bulb Shed Office. Test bulbs will then be returned to the containers. Upon completion of the trial bulbs will be stored & contained in the on site grading room in the event that another field study is applied for.

Performance Standard 4 : Viable vector agent
No vector agents were used, transformation was by gene gun.

Performance Standard 5 : Persistence in Environment
Test material shall remain in the field plots for the duration of the test. Test site will be isolated on the field border on the southern most edge of the field. Rows adjacent to the plots contain the UC Davis nematode trial. The entire test area is surrounded by unplanted blank rows on all 4 sides (see Excel map). ELRF routinely keeps hundreds of test plots, both new plant varieties & testing of pesticides, from getting mixed up through a system of mapping and staking each plot, combined with physical separation. Plot planting and harvesting is done with a small one row digging machine and hand labor into and out of marked field crates. Easter lilies are self-infertile due to incompatibilities in the long floral pistil, thus they never cross-pollinate or produce seed in the field environment. In addition we will remove flower stalks to prevent release of pollen. Easter lilies also do not cross with any wild relatives or weeds. The location is not prone to flooding, animal incursion, or public access.

Performance Standard 6: Termination of Volunteers
Test plants will be removed from the field into their marked field containers; none will be left in the field. Our standard post harvest field treatment consists of deep plowing, multiple disking, culti-packing with a steel roller crusher**,** then planting a cover crop of rye grass and clover.
Easter lily bulbs do not persist under these conditions. The cover crop is then routinely mowed for a period of three years before the field is returned to bulb production. Prior to bulb production the field is again deep plowed, disked and packed multiple times and then fumigated. The fumigants used (Metam Sodium & Telone) will kill any surviving bulb material, although after these procedures there are no bulbs left to kill.

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Persistence in the environment:
The bulbs will be dug up and removed from the field at the end of the field study. They will be stored in a locked area in the event that another field study is applied for.
Volunteer plants:
After the field trial, the Volunteer Monitoring Area will be visually checked for 12 months, every 3 months to determine if any bulbs were lost from the containers and germinate. Any bulbs that germinate in the area will be collected and autoclaved. Any unusual occurrences during this field study and following time period of monitoring the area will be reported to APHIS.

Easter Lily Research Foundation

OF THE PACIFIC BULB GROWERS ASSOCIATION
"Quality Lilies Through Cooperative Research"

DESIGN PROTOCOLS : Nematode Resistant Easter Lily Field Trial (App # 436422)

Performance Standard 1 : Shipping and maintenance at destination:
Plants are maintained in vitro at USDA Beltsville and will be shipped by FedEx in Magenta jars containing Murashige and Skoog's medium under sterile conditions. Magenta jars will be sealed with a pressure sensitive tape and also Scotch magic tape. All jars will be placed in a plastic bag as secondary protection in case of accidental release. Jars will be shipped by FedEx directly to Lee Riddle, manager of the Easter Lily Foundation in Brookings, Oregon 97415 15636 Highway 101 South; Tel: 541-469-2215; email: easterlilyresearch@gmail.com). USDA will ship a total of 120-240 jars of lilies (40 jars/plant line). They will be marked as follows:
(1) Non-transformed line: Nellie White (NW)
(5) Transgenic lines: Cys-11, Cys-25, Cys-55, Cys-59, Cys-71
The shipment will be placed in locked office storage upon receipt at Easter Lily Research Foundation Station (ELRF). Field test planting will commence as soon as weather allows, the next day if possible. Field plots will be pre prepared waiting the arrival of test material. Test plot location is 30 feet in front of the ELRF office door & desk window allowing visual oversight of test plot during working hours. The ELRF research station is fully fenced and the gate is locked when staff are not present. There is a 1000 foot private road from the gate to the research office / test site. There is no public access. Fenced, gated farm fields producing cattle, hydrangeas, hay, & lilies surround the station.

Performance Standard 2 : Inadvertent mixing of material in environmental release
All plants will be planted in a plot outside. Plants will be placed in a container in the soil, and each container placed in the ground with about one 5 cm of the pot edge above ground level. Each container will be marked with waterproof marker on aluminum tags riveted to the container. The planting will be mapped. Refer to attachment map (excel file) for proposed test site marked in green. "Remay" cloth cloches will cover the planting as it adapts from test tube to outdoor conditions. Test plot shall be located on the field edge one row away from other field planted lilies. Adjacent plots are harvested by a combination of hand and single row equipment and will be harvested before the test plots. Test plots will be harvested by lifting the containers from the soil. This will enable one to determine location of the plants, and all bulbs planted will be contained within each pot when it is time to harvest the bulbs. This is not a food or feed crop and will not enter the marketplace.

Performance Standard 3 : Identity of Regulated materials
Plants will be kept inside the marked & mapped field containers for the duration of the trial. At harvest (October 2014) the containers will be brought into the office/ bulb shed facility where the bulbs can be removed from the containers. Dr. Becky Westerdahl, Nematologist at UC Davis, will analyze root samples obtained from test bulbs on site, in the Bulb Shed Office. Test bulbs will then be returned to the planting containers and replaced in the test site for a second growth period. Upon completion of the trial bulbs will be stored & contained in the on site greenhouse in the event that a second year field study is applied for.

Performance Standard 4 : Viable vector agent
No vector agents were used, transformation was by gene gun.

Performance Standard 5 : Persistence in Environment
Test material shall remain contained in the field container for the duration of the test. Test site will be isolated on the field border nearest the office window. ELRF routinely keeps hundreds of test plots, both new plant varieties & testing of pesticides, from getting mixed up through a system of mapping and staking each plot, combined with physical separation. Plot planting and harvesting is done with a small one row digging machine and hand labor into and out of marked field crates. Easter lilies are self-infertile due to incompatibilities in the long floral pistil, thus they never cross-pollinate or produce seed in the field environment. In addition we will remove flower stalks to prevent release of pollen. Easter lilies also do not cross with any wild relatives or weeds. The location is not prone to flooding, animal incursion, or public access. There can be occasional high winds but test plots will be protected as they will be planted next to a large two story office / shed, and covered with cloth during the field adaptation phase.

Performance Standard 6 : Termination of Volunteers
Test plants will be removed from the field in their field containers, none should be left in the field. Our standard post harvest field treatment consists of deep plowing, multiple disking, culti-packing with a steel roller crusher**,** then planting a cover crop of rye grass and clover. Easter lily bulbs do not persist under these conditions. The cover crop is then mowed for a period of three years before the field is returned to bulb production. Prior to bulb production the field is again deep plowed, disked and packed multiple times and then fumigated. The fumigants used (Metam Sodium & Telone) will kill any surviving bulb material, although after these procedures there are no bulbs left to kill.

Persistence in the environment:
Containers with the bulbs will be dug up and removed from the field at the end of the field study. They will be stored in a locked area in the event that a second year field study is applied for.
Volunteer plants:
After the field trial, the Volunteer Monitoring Area will be visually checked for 12 months, every 3 months to determine if any bulbs were lost from the containers and germinate. Any bulbs that germinate in the area will be collected and autoclaved. Any unusual occurrences during this field study and following time period of monitoring the area will be reported to APHIS.

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ROOT SCORE KEY

2013 Season Irrigations Applied

Rocky Hill Vineyard	Holleman Vineyard
4 gallons per week = normal	6 gallons per week = normal
Test Vines received 92 gallons per plant for the season	Test Vines received 138 gallons per plant for the season
Control Vines received 128 gallons per plant for the season	Control Vines received 192 gallons per plant for the season
Saving: 36 gallons per plant	Saving: 54 gallons per plant

2014 Season Irrigations Applied

Delatreca Vineyard

6 gallons per week = normal

Test Vines received 86 gallons per plant for the season

Control Vines received 138 gallons per plant for the season

Saving: 52 gallons per plant

El Portal Vineyard
Variable and dependent on growth stage of vines = normal

Test Vines received 46 gallons per plant for the season

Control Vines received 39.5 gallons per plant for the season

Deficit: -6.5 gallons per plant

CDFA SPECIALTY CROP GRANT LITERATURE REVIEW

2012 Specialty Crop Grant

ABSTRACT

Literature review of methods for measuring nitrate leaching below the root zone including purpose, commodities on which the method has been used, measurement depth/soil type restrictions, sample period, drawbacks, benefits, results and the reference(s) from which the information was obtained.

Coalition for Urban/Rural Environmental Stewardship

1 BACKGROUND

A large portion of the Central Valley and Central Coast sits on top of groundwater that has a concentration of nitrate that exceeds the Maximum Contaminant Level, the concentration of nitrate considered unsafe for consumption by at risk groups (e.g. infants). Agriculture is assumed to be a major source of that nitrate as a result of fertilizer applications (synthetic and manure) and dairy operations that leach nitrate to groundwater. Nitrogen fertilizer is essential for plant growth and must be applied to guarantee reasonable yields, but it is not clear how much of the applied N is used by the crop and how much is lost to groundwater. Leaching is a function of local conditions such as soils and management of irrigation water and nitrate applications.

As part of regulatory programs across the state, many growers must estimate the amount of nitrate leaching past the root zone and eventually reaching groundwater. For example, in the Central Valley, Coalitions of growers must implement a Management Practice Evaluation Program (MPEP) to determine whether existing site-specific and/or commodity-specific agricultural management practices are protective of groundwater quality. Because so little is known about the effectiveness of management practices in preventing leaching of nitrate past the root zone, the MPEP is envisioned as the vehicle for developing studies that will provide that critical information.

The first step in evaluating the efficacy of management practices is to measure the amount of nitrate moving through and past the root zone in the field. The agricultural coalitions in the Central Valley must find an accurate and cost-effective method of measuring the concentration of nitrate moving past the root zone that will allow them to evaluate a potentially large number of fertilizer and irrigation management practices.

The Coalition for Urban/Rural Environmental Stewardship (CURES) is working with the California Department of Food and Agriculture (CDFA) to identify a method of measuring the concentration of nitrate moving past the root zone and applying that method to evaluate selected management practices. Specifically, "This project will identify and pilot test scientific methods capable of measuring the movement of nitrates beyond the root zone of an irrigated specialty crop when used in combination with proven nitrogen BMPs".

This Technical Memorandum is the first step in the process of identifying and testing potential methods. In this Technical Memorandum are the results of a literature review and correspondence with experts in agriculture used to identify methods which will then be used to evaluate nitrogen BMPs under field conditions. Also included in the review is a discussion of monitoring design elements and additional data that should be collected in the field to allow an estimate the amount of nitrate leaching to groundwater.

2 MEASUREMENT OF VADOSE ZONE WATER

Accurately estimating the amount of water and solutes moving through the vadose zone is difficult because 1) spatial variability in flows can range over four orders of magnitude, 2) attempts to measure flow can disrupt the natural downward movement of water causing flows to either divert or converge to the measurement device, and 3) there are no standard methods for estimating flow (Gee et al. 2004). In an attempt to identify a method that can be used across a variety of conditions in agricultural regions in California, CURES initiated obtained information from several experts and the literature to provide the critical information necessary to select an appropriate method for measuring the concentration of nitrate leaching past the root zone.

2.1 INFORMATION OBTAINED FROM EXPERTS IN THE FIELD

Several experts in fertilizer and irrigation management were contacted with a request for information. From that list, six experts were willing to provide information (Table 1). Several of these experts have or are currently collecting data on the concentration of nitrate in the vadose zone in production agricultural fields. The also represent a diversity of skills from crop nutritional status to monitoring design. In some instances, the experts were interviewed by CURES while other experts provided the results of research they had previously conducted on the amount of nitrate leaching past the root zone.

Table 1. Experts contacted for information about measurement of nitrate in the vadose zone.

Name	Affiliation	Expertise
Murray Clayton	CA Department of Pesticide Regulation	Below ground sampling, modeling
Stuart Pettygrove	UC Agriculture and Natural Resources	Statistical analysis of agricultural studies; sampling designs
Edward Hard	CDFA-FREP	Measurement of nitrate in the vadose zone
Patrick Brown	UC Department of Plant Sciences	Crop nutrient status; measurement of nitrate in the vadose zone
Claude Phene	Independent Irrigation Management Consultant	Measurement of constituents in the vadose zone; irrigation
Becky Phene	USDA-ARS	Measurement of constituents in the vadose zone; irrigation

CURES also conducted a literature review to identify a wide range of potential vadose zone sampling methods and generate sufficient information, that when combined with the expert opinion, would allow CURES to select the methods that would be tested in the field.

The information obtained from the experts is provided in Table 2, and the list of potential monitoring methods obtained from the literature review is provided in Table 3. Table 3 also contains the benefits and potential problems associated with each of the sampling methods. A discussion of the methods and details are found in the tables and summary below.

There are a number of potential methods to measure the amount of N leaching past the root zone that range from relatively low cost to high cost and relative invasiveness. The methods also vary in their ability to understand the impacts of management practices on leaching potential.

2.2 Measurement options

2.2.1 Groundwater sampling

The most direct method of measuring the concentration of nitrate in groundwater is to sample wells that obtain water from the aquifer in question. Groundwater wells are expensive and there is a time delay between current between the impacts of currently implemented management practices and changes in the concentration of NO_3 in the well water. In fact, depending on the depth of the well, the delay between activities on the surface and changes in concentration in the aquifer may be decades. Also, because of horizontal flow paths and flow velocities, the concentration of nitrate measured from samples collected today may reflect practices up-gradient that were implemented several years or decades ago.

Other techniques involve either removing a sample for measurement or placing an instrument in the soil to measure the amount of nitrate at that location. In addition, there are tracer methods that allow tracking of nutrient applications and can provide an understanding of the movement of nutrients in the environment.

2.2.2 Ion exchange resins

Cationic and anionic exchange resins involve placing a block containing the exchange resin into the soil profile at a specific depth. These resins often are in the form of beads and the particle size distribution can range from approximately 0.3 mm to 1.2 mm (http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_0032/0901b803800326ca.pdf?filepath=liquidseps/pdfs/noreg/177-01837.pdf&fromPage=GetDoc) as either a uniform size or a variable size "package" of beads. To reduce disturbance, the resin is often placed in a shaft that is excavated at a 45^o angle from the surface. The resin must be extracted periodically for the measurement of the bound ions and new resin replaced. After each extraction, the excavation hole must be packed to eliminate a selective flow path that allows surface water to directly reach the exchange resin.

Conventional ion exchange resins consist of a cross-linked polymer matrix with a relatively uniform distribution of ion-active sites. They are placed in the soil where soil moisture containing ions comes into contact with the resin beads. The ions bind to the resin in a reversible reaction. When removed from the soil, the ions are extracted from the beads allowing a measurement of the concentration of the various ions in the pore water. Nitrate removal from contaminated water can be accomplished using essentially the same technology.

Exchange resins integrate a signal over the period of time in which they are left in the soil provided the capacity of the resin beads is not reached, i.e. the ion exchange sites are not filled prior to extraction of the beads from the soil. As a result, the concentration of ions (e.g. nitrate) measured from the exchange resins does not reflect the concentration of ions measured in soil cores or samples collected from suction lysimeters because soil cores or lysimeter samples are snapshots in time.

2.2.3 Nitrate sensors

Nitrate specific probes can be installed in groundwater wells, tile drains, and directly in soils. They can be installed and operated remotely or portable and lowered into groundwater during sampling. As with sensors and probes placed in any natural environment, permanent probes can experience fouling and sensor drift. However, because there is no light available to promote algal growth and groundwater is a relatively microbe free medium (contamination by septic or dairy operations notwithstanding), fouling is not expected to be a major problem. Sensor technology can be expensive and less accurate than laboratory N tests, particularly for high N concentration. However, permanent sensors can provide real time monitoring if high frequency measurement is needed or desired.

2.3 LYSIMETERS

Lysimeters are devices that are placed at a specific depth in the soil to sample water reaching that depth. That water can be removed and sent to a laboratory for analysis for any number of constituents desired.

2.3.1 Suction lysimeters

Suction lysimeters are relatively inexpensive equipment that can sample water moving through the vadose zone at depths that range from a few inches to several feet. Suction lysimeters are often in the form of a long stainless steel tube with a ceramic cup at the end. The ceramic cup has small perforations that allow molecules of a specific size through the ceramic wall into the cup allowing some specificity in the constituents sampled. The lysimeters are installed by inserting them into a core placed into the soil. Sampling occurs by pulled pore water from the surrounding soil into the cup through the ceramic walls when suction is placed on the lysimeter. Depending on other instrumentation associated with the lysimeter, sampling can occur continually, in response to the presence of pore water at the depth of the lysimeter, or at preset times. Often, suction will be placed on the lysimeter and water allowed to enter the cup for some period of time, e.g. 24 hours. Once water is pulled into the cup, it can be removed by pumping it into a sample container and sent to the laboratory for analysis.

Suction lysimeters are very easy to install, very easy to use, and require very little additional equipment to obtain a sample. Lysimeters can pull a sufficient sample volume to analyze by standard laboratory techniques but if installation is not done properly, water from the surface can migrate down the core to the ceramic cup, i.e. a preferential flow path can be associated with the core due to improper installation. Also, it is not possible to estimate the volume of soil sampled because the effectiveness of the suction depends on the porosity of the soil at the depth of the lysimeter cup. Consequently, water flux must be estimated using another method (16).

2.3.2 Suction plate/tension plate lysimeter

As the name implies, a suction plate lysimeter is a plate that pulls pore water from the surrounding soil while under tension. In some applications, the tension on the plate is constant, while in other applications the tension is varied to ensure collection of any soil pore water that results from the downward movement of water associated with rainfall or irrigation events. Like standard suction lysimeters, tension plate lysimeters can efficiently collect a large amount of sample that can be removed for analysis. Tension plate lysimeters can range in size from 15 cm in diameter to relatively large, e.g. 0.25m x 1 m. Because of their size, their installation requires removal and disturbance of a much larger volume of material that is more likely to produce a preferential flow path through the soil profile. To minimize soil disturbance, tension plate lysimeters can be inserted horizontally into the soil profile at the desired depth although this technique requires that the insertion point be accessible from the horizontal plane.

2.3.3 Zero tension lysimeter

Zero-tension lysimeters (or gravity lysimeters) are instruments for measuring the flow of water and solutes through the soil profile. If placed below the root zone, these instruments can estimate the flux of water and the constituent of interest. This flux is assumed to estimate the volume of recharge to groundwater. Zero tension lysimeters suffer from the same issues as tension plate lysimeters in that their installation can disturb a large amount of soil which can affect their ability to collect “natural” samples for several years.

2.3.4 Capillary wick lysimeter

A wick (or capillary wick) lysimeter controls the tension at the interface of the drainage surface by using an inert wicking material such as fiberglass or rock wool. Essentially, the wick pulls water from the overlying soil as the water comes into proximity of the lysimeter (see Figure 1). The water enters a collection container below the wick. The water is then removed by suction to a sample container and the sample can be transported to the laboratory for analysis. These devices are relatively inexpensive and easy to install but also suffer from the problem of significant soil disturbance.

Figure 1. Capillary wick lysimeter design. Taken from Gee et al. 2004 (17).

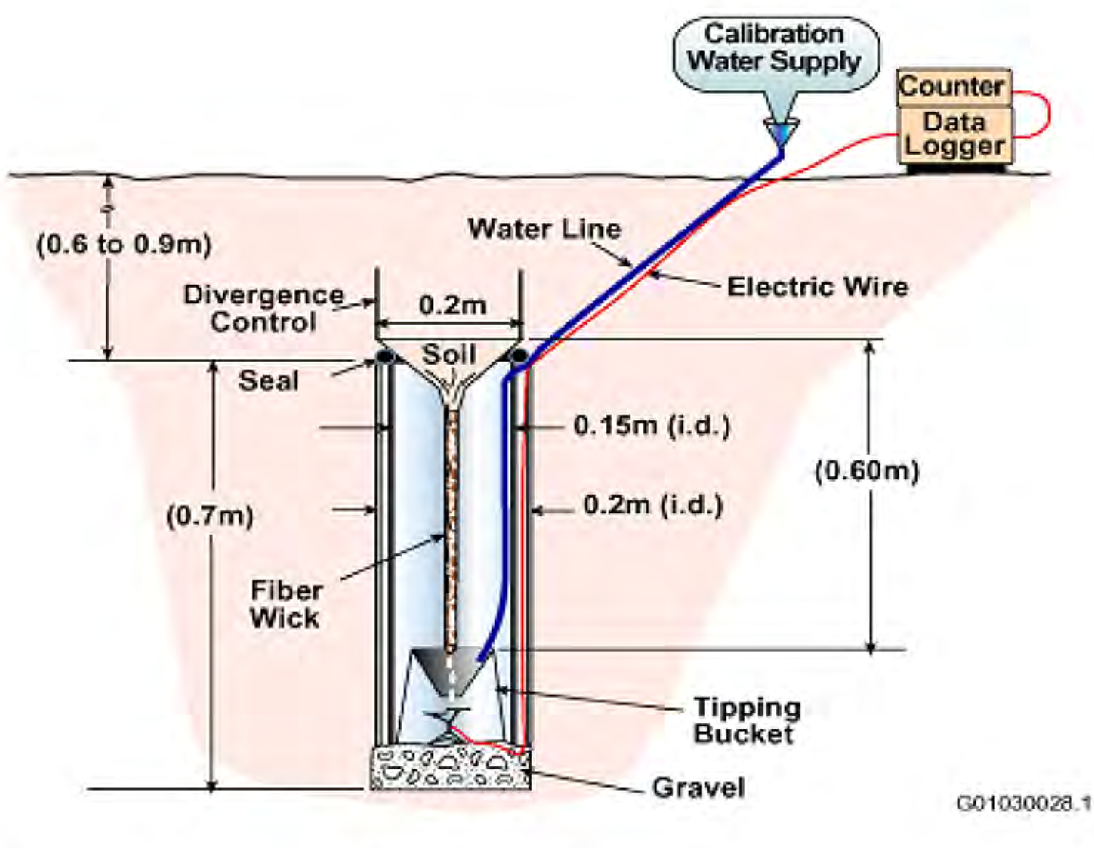

Figure 1. Schematic of a passive-wick WFM.

2.3.5 Soil cores

Soil cores have been used for decades to measure the amount of various constituents in the vadose zone. Collecting soil cores is relatively simple and inexpensive. They can be collected by hand in most soils although in heavier soils, power equipment can be useful in obtaining a core in a short time. Cores have the benefit that they sample the entire length of the soil profile from which the core is extracted and the number of vertical samples is limited only by the analytical requirements of the chemical test. Conversely, soil from sections of the core, or the entire core, can be homogenized and representative concentrations of constituents from the entire profile can be developed. Soils cores are destructive in the sense that soil removed alters the field and can result in the development of preferential flow paths for surface water to reach groundwater. Repeated coring over time and space could potentially alter the overall movement of water through the vadose zone in the field.

2.3.6 Tracers

Tracing the movement of water and nitrate through the vadose zone and into plant material can be estimated using tracers of water and nitrate movement. The stable isotope of nitrogen, ^{15}N, can be used to trace the movement of nitrate in the environment. ^{15}N can be incorporated into nitrate fertilizer or added as a separate tracer in its natural form. Because of the fractionation of nitrogen as a result of metabolic processes, the mass balance of ^{15}N is not easy and requires an understanding of the natural ^{15}N concentration in the soil profile. Also, the use of ^{15}N as a tracer can be expensive and the analysis of samples for ^{15}N requires specialized instrumentation. While the analysis is not particularly expensive, it is not commonly done in contract analytical chemistry laboratories.

Chloride as can be used as a tracer of water movement. It is inert and not used by biota in any significant amount. Chloride tracer methods are relatively easy to implement and chloride is inexpensive to measure. Numerous chloride probes are available for measuring chloride in the field. Often used to estimate groundwater recharge, a chloride mass balance approach can be used to estimate the amount of irrigation water moving through the root zone if a sufficient number of measurements are collected for the amount of chloride in the soil and irrigation water.

3 ADDITIONAL INFORMATION

A consistent message from the experts interviewed was that nitrate leaching should be measured by multiple techniques (e.g., lysimeters, ^{15}N tracers, soil cores, shallow wells) to compare results (Edward Hard, Patrick Brown). Because of the potentially large amount of heterogeneity in the soils in a single field, numerous samples need to be collected. To account for the variability in a field, a random or stratified random monitoring network is best for characterizing nitrate leaching (Stuart Pettygrove). Measurements should be made concurrently with measurements of crop nutrient status and growth stage, along with management practices applied so that results can be used to make recommendations for future fertilizer and water management (Edward Hard, Patrick Brown). Temporally, samples should be collected to coincide with the application of water and fertilizer. Finally, the statistical analyses used to evaluate the data are as important as the monitoring design (Stuart Pettygrove).

Table 2. Information from experts in nitrogen and irrigation management.

Name	Affiliation	Tools	Method	Monitoring techniques
Murray Clayton	CADPR	Modeling (http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/probabilistic_model.pdf)	Direct	Lysimeters (current research, not used for model ground-truthing), public access data from domestic wells (mentioned online as the way the model was ground-truthed).
Stuart Pettygrove	UCANR	Statistics	Direct	Not as important as statistics
Edward Hard	CDFA-FREP	$^{15}NO_3$ as a tracer, early season sampling vs. proposed "pump and fertilize" strategies, modeling (Hydrus), monitoring wells, nutrient budget, direct soil and soil solution sampling	Referred to grant proposal	Pore water sampling using lysimeters with transducer at cup, groundwater sampling, ^{15}N tracers, shallow wells, soil sampling, plant tissue sampling, root distribution, modeling (N budgets, vadose zone hydrology)
Patrick Brown	UC Davis	$^{15}NO_3$ as a tracer, early season sampling vs. proposed "pump and fertilize" strategies, modeling (Hydrus), monitoring wells, nutrient budget, direct soil and soil solution sampling	Referred to grant proposal	Pore water sampling using lysimeters with transducer at cup, ^{15}N tracers, shallow wells, soil sampling, root distribution, modeling (N budgets, vadose zone hydrology)
Claude Phene	Independent Consultant	Statistics, aerial photos for assessing in-field variability, minimum of 9 stations per 40 ac field	Direct	UMS pore water sampling systems
Becky Phene	USDA-ARS	UMS controller for pore water sampling will minimize temporal sampling error	Direct	UMS pore water sampling systems

Table 3. Methods available for sampling nitrate in the vadose zone.

Technique	Purpose	Commodities	Measurement Depth, preferred soil type	Sample Period	Drawbacks	Benefits	Results	Reference
Suction Lysimeter (two types listed below)	Sample nitrate in root zone to develop nitrogen balance	Almonds, hardwood trees, row crops (tomatoes, corn)	Non-structured soils[1]	Irrigation and winter rainfall	Need reasonable soil moisture, may be technical issues with sampling efficiency[2] uncertainty in the ability of ceramic porous cups to absorb anions, such as (NO_3^-)[4]	Low expense relative to wells, ability to sample various depths to understand what is happening across soil profile; easy installation[2]; most commonly used[2]	1975 study indicated poor representation of nitrate concentrations compared to soil concentrations due to sampler intake rate, sampler depth, plugging and vacuum type. Suggestions included short sampling intervals, uniform sampling lengths[4].	**1,2, 4**
Pore water sampler/suction cup (w/ vacuum)	Solute concentration[2;] Soil water chemical analysis[12]	Tomato[5] banana, sugarcane[11]	Well-drained, sandy, loamy soil[2], 1 m depth[11]			Simple design[2], low-mid cost[2], easy to install[2]. Best for concentration sampling[2]. Easier to install than plates[12]. Usable at high depths[12]. Deep installations at defined vacuum[12]. Low dead volume[12]	"Best" cup samplers for soil solution sampling are ceramic cups due to low failure rates, adequate volumes of solution and minimum soil alterations[4]. Nitrate leaching was measured in irrigated vegetable crops in typical xerofluvent soils using ceramic porous cups (1 m depth). Nitrate showed highest leaching rates during crop establishment due to previous N mineral content already in the soils[5]. Suction lysimeters were installed on banana and sugarcane crops using ceramic cups and a vacuum that supplied 16kPa to the cups. Nitrate concentrations varied between each lysimeter, even if the drainage volumes were somewhat uniform. Deep drainage of sugarcane crops measured by lysimeters was compared to the *Watersense* daily balance model and the lysimeters were found to "adequately capture deep drainage"[11]. Deep drainage did not occur on banana crops until 21-86 days after fertilizers were applied[11].	**2, 5, 11, 12**

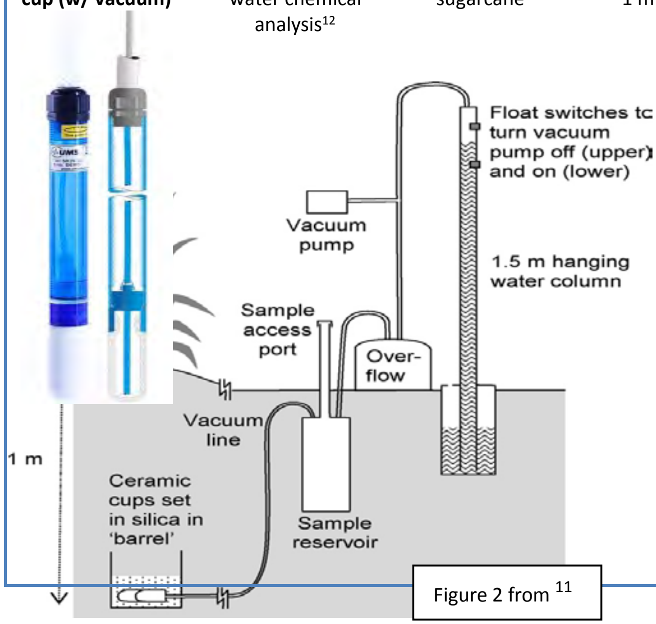

Figure 2 from [11]

Technique	Purpose	Commodities	Measurement Depth, preferred soil type	Sample Period	Drawbacks	Benefits	Results	Reference
Suction plate/tension plate lysimeter 	Nitrogen balance; solute transport[2]; hydrologic loading [12]		52 cm depth, Sandy soils[7]		Plates interfere with natural flow creating variation in solute concentrations[2] Costly[2]	Extracts solution from top, bottom and side[12]	Tension-controlled plates when compared to wicks, resin boxes provided the best means for measuring solute leaching[7]	**2, 7, 10, 12**
(Passive sampler) Capillary Wick lysimeter	Solute transport[2]		Sandy, dominant preferential flow [3]	Only useful in well-structured soils; low suction capacity led to poor results[3]	Variations in wicks for hydraulic, chemical and sorptive properties[2]	Leachate collection efficiencies have equaled 100% in several field tests[2]; low cost [2]	Wicks worked well under higher irrigation volumes (5 mm h^{-1}) but water recovery was significantly lower at lower irrigation (2.4) volumes probably because the soil suction exceeded the capillary force of the wick[7]	**2, 3, 7**
(Passive sampler) Zero tension /pan lysimeter	Solute transport[2]		Saturated[4]; Need soil moisture[2]; soil w/ large macropores[2]		Fails to collect solutions in unsaturated conditions; large soil disturbance[4]; Unsuccessful if soil is dry[2]; high variability in solute concentrations due to water divergence[2]; difficult to install, much disturbance[2]	Low cost[2]; easy maintainance[2]		**2**
N15 Tracer	Nitrogen balance, tracer of applied nitrogen	All crops (almonds, pistachios, grapes, tomatoes, cotton, legumes, pasture, soybeans); corn and eggplant[6]	15, 45, 75 cm[6]; vadose zone	Anytime	May need significant volumes meaning restricted areal coverage, additional analytical expense, must account for natural ^{15}N	If used in significant amounts, can be easily detected in any medium, good tracer	^{15}N was injected at 15, 45 and 75cm into alluvial soils. Peak ^{15}N levels appeared at similar soil depth after harvest of both eggplant and corn even though labeled nitrate was injected at different depths. The deeper the ^{15}N-labeled injection, the smaller the distance of downward movement. The results could be explained by soil water movement during rainfall [6]	**6**

Technique	Purpose	Commodities	Measurement Depth, preferred soil type	Sample Period	Drawbacks	Benefits	Results	Reference
Cl^- Tracer	Solute leaching tracer						Cl^- was used as a tracer to compare wick, suction plate and resin box samplers for measuring solute leaching. Suction plates showed little variation between the recovery of Cl- and water however dispersion of Cl^- was observed[7]	**7**
Monitoring Well	Constituent monitoring, groundwater level	Any	Any depth	Anytime	Expense, travel time from surface difficult to understand without additional analysis work	Allows measurement of constituents at location of regulatory compliance		
Nitrate sensors for wells	Alternative to manual well sampling[9]			Any or continuous	Cost =~$1500[9]	Operate remotely, somewhat rugged, eliminates sampling costs, real time data[9]	An environmental technology verification for nitrate sensors was performed by Battelle for the EPA and showed that the Mean Absolute Error increased with increasing nitrate concentrations; the Regression Point Displacement tests showed that field sensors measurements were within 15 % of lab sensor messurements[9]	**9**
Soil Augering/core	Remove volume of soil from specific depth	Corn, sorghum, wheat, rice, other grains, forest trees, tree plantations, wetlands; nectarine orchard[5]	Up to 2 m;	Anytime	Hand augering may be difficult in heavy soils, post-processing of soils necessary; destructive to soils[1]; only provides a snapshot of N distibution[1]	Sample from a known soil depth	Similar total nitrate concentrations were found when soil cores were compared to porous cup samplers however differences in concentrations were observed at certain depths due to spatial variability in cores[4]. During a study measuring nitrate in loam- clay soils in deep vadose zones (15.8 m) using cores from a direct-push drilling rig, a high number of non-detects and overall a low amount of N stored below the root zone was found. Results may be due to localized denitrification in slow flow zones, preferential flow and fingering leading to localized N transport; highly variable soil properties [5]	**1,4, 5**

Technique	Purpose	Commodities	Measurement Depth, preferred soil type	Sample Period	Drawbacks	Benefits	Results	Reference
Drain Tile Water Analysis	Nitrogen loss from agricultural fields;	Corn, soybeans	1.5 - 1.9 m	Elevated groundwater or irrigation season	May need to break into tile system to sample	Removes water very soon after application		
Modeling	Understand concentration of constituents in vadose zone	Almonds; sugarcane[8]; corn, soybean[9]	NA	NA	May need lots of data to calibrate and validate; difficult to calculate N around the capillary zone because of the potential of that zone to retain groundwater, therefore the nitrate flux will not represent concentrations from the root zone[8] excess or low rainfall conditions have a tendency to affect model predictions[9]	Once calibrated, can be used to simulate different management scenarios	Agricultural Production Systems Simulator-SWIM (APSIM) was used to predict nitrate leaching from the root zone in sugarcane. Modeling results were compared with soil cores at 1.5 m depths in sandy soils. The model proved to be mostly in unison with the observed nitrate values, minus some temporal variation[8] Comparison between measured NO_3^- subsurface drainage water concentrations and the Root Zone Water Quality Model(RZWQM) in corn and soybean showed an 80 % efficiency and 13% difference between measured and predicted data[9]	**8,9**
Cationic and anionic exchange resins	Measure NH4+ and NO3- below the root zone	Turfgrass, tallgrass prairie	Below root zone, sandy loam to loam	1 yr	Resin installation and removal must be done monthly. Installation involves re-sealing access hole at 45 degree angle. Post-processing required once resin is removed from soil. Recovery varies depending on resin exchange properties, time (14). Less accurate than suction plate (7). Poor correlation with soil samples because "both capsules and probes represent more of an integrated and perhaps cumulative measure of soil N availability over time whereas the soil mineral N measurements are snapshots at discrete intervals (15)."	No maintenance during equilibration (14), nondestructive (15).	"Nutrient leaching was found to be a function of fertilizer source, time, soil infiltration rate, shoot density, and antecedent soil moisture. (14)". Leaching losses correlated with early establishment when canopy cover was lowest, particularly in plots fertilized with readily available N sources. N balance calculations in some cases recovered more N than applied due to carry-over from prior seasons (14). Resin probes and capsules failed to capture N mineralization during incubation because they integrated N concentrations over time with poor temporal resolution (15).	**14**

4 RECOMMENDATIONS

Based on the literature review and discussions with experts using many of these techniques, suction lysimeters are seen to be the most appropriate method of obtaining nitrate samples from the vadose zone. Suction lysimeters are selected because they:

- Lysimeters are relatively inexpensive to purchase and install
- Require little additional equipment to operate
- Involve minimal disturbance to the field
- Reduce the potential for preferential flow paths to develop
- Can be combined with other equipment to automate the sample collection process

For the field portion of the study, two types of suction lysimeters will be tested. A simple suction lysimeter will be installed in fields of two different crops, lettuce and walnuts. In addition, two UMS (Decagon, Inc.) suction lysimeter systems will be installed in lettuce and walnuts. The two types of systems will be compared with respect to:

- Ease of installation
- Ease of operation
- Reliability

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CDFA SPECIALTY CROP GRANT FINAL REPORT ADDENDUM

2012 Specialty Crop Block

ABSTRACT

Addendum to the CURES CDFA Final Report including an evaluation of methods and results of Phase I and Phase II of the grant project.

Coalition for Urban/Rural Environmental Stewardship

1 INTRODUCTION

1.1 PURPOSE/BACKGROUND

The purpose of the CDFA Specialty Crop Grant was to evaluate the efficacy of management practices at reducing nitrate leaching below the root zone in California specialty crops.

Growers enrolled in the Irrigated Lands Regulatory Program are required to minimize or eliminate leaching of nitrate below the root zone of crops to prevent groundwater contamination. Currently, there is little understanding of what quantity of nitrogen leaches to groundwater, and the effectiveness of nitrogen management practices in preventing leaching. In Phase 1 of this study, cost effective equipment to measure nitrate leaching below the root zone was established using equipment deployed in fields of two specialty crops in two soil types. In Phase 2, spatial and temporal sampling protocols to measure nitrate leaching were developed and incorporated into a methodology to be provided to growers, Coalitions and commodity groups. The protocols will allow parties to measure the ability of management practices to minimize or eliminate leaching of nitrate below the root zone, and to establish best nitrogen management practices for specialty crops on irrigated lands in California.

In the first year of monitoring, two types of suction lysimeters were selected for comparison: an automatic suction lysimeter (UMS) and a manual suction lysimeters (Irrometer). Both instruments were installed in four different fields and samples were collected and analyzed for nitrate. Part of the evaluation to determine which method is best includes a review of cost, reliability, and variability in results based on field situations (soil, crops, and irrigation methods). In year 1, manual suction lysimeters proved to be the most reliable method of obtaining samples.

Knowing that suction lysimeters can capture and measure the amount of nitrate moving through the root zone provides some validation of the utility of the equipment. However, the lysimeters must be able to detect differences in the amount of nitrate moving past the root zone in response to different management practices applied to fields. The inherent variability in the saturated hydraulic conductivity of soils in large fields makes characterizing nitrate leaching across the field a difficult task. Detecting differences between practices when dealing simultaneously with variability in soil across a field is a critical aspect of evaluating the efficacy of management practices designed to reduce nitrate leaching. The work to be performed in the upcoming growing season is to determine if suction lysimeters can detect differences between fields that are managed differently. In this field trial, the different management practices are 1X and 2X fertilizer application rates. These treatments represent a relatively large difference in nitrogen inputs and should be detectable by the lysimeters.

2 PHASE I METHODS

2.1 CROP SELECTION

Two specialty crops were selected for Phase I; walnuts and broccoli. Walnuts were selected as a specialty orchard crop grown in the Central Valley, and broccoli was selected because of the significant acreage in the Central Coast region. Because of the crop rotation in the broccoli fields, the studies were performed on fields where the current crop was lettuce (one field rotated to cauliflower during the trial).

2.2 FIELD SELECTION

2.2.1 Ingress/Egress Agreements

Prior to the selection of individual fields, several growers were contacted about the possibility of using their fields for the study. Because installing the equipment had the potential to cause disruption to the lettuce crop, growers had to agree to allow the destruction of a small number of individual plants. Cooperating growers were located and ingress/egress agreements were developed and executed between the growers and CURES.

Once cooperating growers were identified, a walnut orchard near Stockton and lettuce fields near Gonzales, Salinas, and Santa Maria were selected for study. A summary of the characteristics of the fields and the study design are found in Table 1.

Table 1. Summary of study field characteristics.

Location	Stockton	Salinas	Gonzales	Santa Maria
Crop	Chandler Walnuts	Romaine Lettuce	Romaine Lettuce / Cauliflower	Romaine Lettuce
Soil Type	Boggiano Clay Loam	Chualar Loam	Mocho Silt Loam	Tujunga Loamy Sand
Capacity of the most limiting layer to transmit water, Ksat (in/hr):	Very low (0.0)	Moderately high (0.2-0.57)	Moderately high to high (0.57-1.98)	High to very high (5.95-19.98)
UMS Automated Samplers				
Number installed	1	1	1	1
Depth, ft (shallow, deep)	4, 7	4, 8	4, 8	4, 8
Target Suction, kPa (shallow, deep)	67, 67	40, 55	25.5, 54.6	60, 60
Irrometer Manual Samplers				
Number of pairs installed	3	3	3	3
Depths, ft	4, 6	2, 4	2, 4	2, 4
Target Suction, kPa (shallow, deep)	50, 75	50, 75	50, 75	50,75
Date Range (2013 - 2014)	July - October	June - August	July -July	August -July
Number of Visits	7	13	9	10
Number of Installations	1	3	2	2
Depth to Water Table, feet	97-150	197-292	62-72	52-70

2.3 LYSIMETER INSTALLATION – DEPTH, DENSITY

Both a manual and a semi-automated method of collecting pore water were chosen for Phase I of the study. The two pore samplers chose were the Soil Solution Access Tube (SSAT) from the Irrometer Company and an automated vacuum sampling system from UMS (Underground Monitoring System).

2.3.1 Irrometer SSAT

The Irrometer SSAT is a lysimeter that consists of a clear plastic body, a porous ceramic tip, a neoprene stopper, a vinyl suction line and plastic suction line clamp. Pore water is pulled through the porous ceramic cup by applying a vacuum to the suction line and clamping the line closed. Installation requires inserting the SSAT into a hole that has been augered slightly smaller than the diameter of the SSAT which ensures a good connection with the surrounding soil.

2.3.2 UMS Systems

The UMS is a tensiometer controlled vacuum system that applies a specified vacuum when a user-set soil moisture level is reached. The UMS system consists of 4 main components; the VS-pro vacuum system, a tensiometer, ceramic pore water samplers, and a set of sampling bottles housed in a field box. The VS-pro vacuum system is capable of operating two independent pore water samplers. Installation requires mounting the control box in or near the field, running vacuum lines to the sampling bottles in the field box and then down to each of the ceramic pore water samplers. This requires a linear trench of various lengths dependent on the crop and location in the field.

2.4 Design - Lettuce Fields

Each of the three lettuce fields[1] selected for study were between 15 and 20 acres in size. Both types of lysimeter systems were installed in all fields in a similar manner. The UMS system control box was placed at the edge of each of the fields and, depending on which field, a trench was dug between about 10 and 13 meters into the field. At the end of the trench, one ceramic pore water sampler was placed at a depth of 8 feet and the other at a depth of 4 feet. The field box with the sampling bottles was placed 3 meters back from the end of the trench and buried to just above ground surface.

The Irrometer SSAT array consisted of three sets of two lysimeters installed at 2 and 4 foot depths. The sets of lysimeters were installed in the shape of a triangle, with the field box of the UMS forming the base of the triangle. Two sets of lysimeters were installed in planted beds on either side of the field box. The third set was installed very near the UMS pore water samplers to provide a comparison of samples collected from two different lysimeter systems in the same location.

2.5 Design - Walnuts

The two lysimeter systems were installed near the northwest corner of the walnut orchard, about 50 meters into the orchard from the eastern boundary. A short trench was dug between two trees, and the UMS control box, field box, and pore water samplers were all installed in close proximity to each other. The ceramic pore water samplers were installed at two depths; one at 4 feet and the other at 7 feet. It was not possible to place the pore water samplers any deeper due to an impermeable clay layer. The three sets of Irrometers were installed approximately 5 meters away from the UMS system; one in the same row of trees and one in each of the rows adjacent to the UMS system.

2.6 Sample collection

Collection of the pore water was timed to occur immediately following irrigation at each field. Just prior to irrigation, any residual pore water was cleared from the SSATs and the UMS sample collection bottles.

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[1] One field was rotated to cauliflower during the course of the study.

A vacuum of approximately 75 psi and 50 psi was put on the deep and shallow SSATs respectively. The UMS vacuum controller was set between 450 hPa and 600 hPa for the deep sampler and 150 hPa to 500 hPa for the shallow sampler, depending on the soil conditions of the respective field.

The collection of the pore water from the lysimeter systems generally occurred at least 16 hours after the vacuum was pulled. Samples were collected from the SSATs by loosening the rubber stopper, opening the finger clamp, using a disposable syringe to pull the water out of the tube, and placing the sample into a container. The syringe was rinsed with deionized water between each collection. Samples from the UMS system were collected by opening the field box, unscrewing the sampling bottle cap, and pouring the sample from the bottle into a sample container.

2.7 Analysis of Nitrate in Samples

All samples were analyzed for nitrate with EPA method 300.0 at Caltest Analytical Laboratory in Napa, California. To meet analytical requirements, the samples were required to be 10 mL in volume or greater, and received at no more than 6^{o}C. Samples were all analyzed within 48 hours of collection.

3 Phase I Results

Samples were collected between July 2013 and October 2014 after irrigation events (Table 2). Since the walnut orchard is a permanent crop, it was sampled past July to increase the number of samples. The number of samples collected varies between sites depending on the number of irrigation events and if water could be collected.

Table 2. Nitrate as N results for samples collected from the UMS and Irrometer sets (shallow vs deep). A blank cell indicates that a sample could not be collected. Non-detect samples are indicated as less than the detection limit (e.g. < 0.1).

Site	Date	Nitrate as N (mg/L)							
		UMS		*Lysimeter Set 1*		*Lysimeter Set 2*		*Lysimeter Set 3*	
		Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Gonzales	8/30/2013	13	170		100		72		130
	9/12/2013	267.9	170		35		4.2	1.8	130
	10/1/2013	230	160						
	10/2/2013	300	180						
	2/13/2014	260							150
	2/26/2014		150		120		170		
	2/27/2014		150		100		170		
	4/2/2014		190						
	4/28/2014		190						
	5/16/2014	260			98				150
	6/1/2014		170		110		210		130
	6/12/2014	330	170		95				120
	6/13/2014		150	59	77		170	95	100
	6/22/2014		140	56	90		160		92
	6/24/2014		130	57	78		160	90	110
	7/10/2014		190	53	94			110	110
	7/16/2014		150	63	81			72	99

Site	Date	Nitrate as N (mg/L)							
		UMS		*Lysimeter Set 1*		*Lysimeter Set 2*		*Lysimeter Set 3*	
		Shallow	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**
	7/31/2014	240	190	84	28		190	68	79
Salinas	7/18/2013		56						
	7/31/2013		76						
	8/30/2013			6.8		6.9	20	29	50
	9/12/2013	56	121			0.21	0.66		39
	10/1/2013	72	140	5.7		5.6	3.5		0.87
	10/2/2013			95		27	100	16	94
	10/10/2013	71		27	13	9.2	47		70
	10/16/2013	42	150	28	5.9	3.3	58	35	110
	11/26/2013		150						
	2/12/2014		140						
	2/13/2014		140						
	2/26/2014		150	0.21	63	59	110		56
	2/27/2014		120	3.5	93	72	120		69
	4/2/2014	98	160		11	13	20		25
	4/28/2014		170						
	5/7/2014		150						
	5/16/2014		170						
	6/1/2014	110	160						
	6/12/2014		250					5.3	
	6/13/2014		230	110				13	
	6/22/2014	150	250	19				0.42	36
	6/24/2014			51	35			23	33
	7/16/2014	100	170					0.088	
	7/31/2014	110	170					<0.01	
	8/4/2014	110	180						
Santa Maria	9/12/2013	60	75						
	10/30/2013	70	70						
	11/6/2013	62	74		28		87	45	43
	11/21/2013	70	65		29		68	5.7	36
	1/16/2014	27	12	0.13	26	6.7	19	0.97	17
	1/27/2014	2.1	18						11
	6/5/2014	58							
	6/24/2014	43	37		54			<0.01	33
	6/25/2014	32	33	46	51		42	7.8	20
	7/16/2014	25	38	<0.01	26	0.64	18	<0.01	0.99
Stockton	7/31/2013		2.5						
	8/13/2013		1	0.046				90	
	3/4/2014					<0.01			
	4/3/2014	5.7	0.2			<0.01	1		
	5/15/2014	4.8	0.32						
	5/19/2014						<0.05		0.089
	5/20/2014						0.26		0.39
	5/21/2014						<0.05		
	8/6/2014			32		150			
	8/27/2014	7.3	0.2						

Site	Date	Nitrate as N (mg/L)							
		UMS		*Lysimeter Set 1*		*Lysimeter Set 2*		*Lysimeter Set 3*	
		Shallow	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**
	9/2/2014	4.6	0.58	3.5		55			
	10/7/2014	1.1	0.39			<0.01			

4 PHASE I DISCUSSION

Both the UMS system and the Irrometer SSATs were successful at collecting pore water samples. In the three lettuce fields, the Irrometers were able to consistently collect samples when a vacuum was applied. However, in really well drained soils such as the field in Gonzalez, the water moves through the root zone quickly and it is important to time the sampling very closely with irrigation. A low tension ceramic tip is available for the SSATs that may aid in collecting pore water samples in coarser soils. In the walnut orchard, which contains less permeable soils than the lettuce fields, the Irrometers were not effective at recovering pore water samples. This could be a result of the Irrometer running out of vacuum before irrigation water was able to percolate through the soil and reach the ceramic cup or due to preferential flow paths within the clay layers that never allowed water to reach the depths of the Irrometers. The Irrometer SSAT are inexpensive, simple, quick to deploy, and can reliably collect pore water samples if sample collection is properly timed with irrigation or storm events. Due to the lower cost of the Irrometer SSATs compared to the UMS, more of the field can be instrumented allowing for sample collection to be more representative of a field with heterogeneous soils and/or permeability.

The UMS system was also able to consistently collect pore water from the 3 lettuce fields but not in the walnut orchard. The key feature of the UMS is the ability for the vacuum system to be controlled by the tensiometer and collect samples automatically when moisture is present. This feature only worked properly on the UMS system installed in the walnut orchard. It did not work at all in any of the three systems installed in the lettuce fields. The tensiometer control works by measuring the difference between the soil moisture and a user defined value and activating the vacuum pumps when the difference in tension is reached. It is believed that this failed to work in the lettuce fields because they were irrigated such that there was no break in the water moving through the root zone and thus the soil stayed too moist for the tensiometer control to work properly. This resulted in a constant vacuum being required to collect any water moving through the root zone which reduced the temporal reliability of the data. Vacuum leaks were also an issue with the UMS system. The setup outlined in the user manual required multiple connections and fittings which increased the likelihood of a leak. Vacuum leaks kept the UMS system from reliably applying the user define vacuum to the pore water samplers and drained the battery quickly. Despite the failure of the tensiometer in the lettuce fields, the UMS was able to collect samples.

5 PHASE II METHODS

5.1 CROP SELECTION

The crop selected for the Phase II field trial was lettuce. Several factors were used to make the decision including:

- Grower cooperation including willingness to allow different fertilization rates on the two treatment blocks
- Short growing season for lettuce
- Accessibility
- Soil conditions on the two treatment blocks

5.2 FIELD SELECTION – MANAGEMENT PRACTICES

During the efficacy testing of the two systems (Phase I), the lettuce field in Salinas produced 85 total samples collected indicating that there was a high likelihood that samples would be collected successfully during Phase II. Due to the simplicity of operation, the ability to deploy quickly, and the ability to address spatial variability, the suction lysimeters (Irrometers) were selected as the equipment to use to measure differences in nitrate leaching from fields with different management practices.

The field is located in the northern Salinas Valley. It is 16.7 acres and the soil types in the field consisted of 78% Chualar loam, 17% Elder sandy loam, and 5% Antioch very fine sandy loam. The field is ripped regularly and tilled prior to each planting. The field was prepped with 36 inch beds and planted in romaine. For this study, the field was split into two 8.35 acre treatment blocks. The north treatment block consisted of mainly the Chualar loam with a little bit of the Elder sandy loam. The south treatment block consisted of mainly the Chualar loam as well, with similar areas of both the Elder sandy loam and the Antioch very fine sandy loam.

After planting, the field was irrigated with sprinklers for about 3 weeks until the roots became established. The sprinklers were removed and the surface drip system was then installed. Until harvest, the lettuce was irrigated and fertigated through the drip line. During the growing season, the North treatment block received 18 gallons of 28-0-0 for a total of 55.5 pounds of nitrogen per acre and the south block received 35 gallons of 28-0-0 for a total of 110 pounds of nitrogen per acre. The fertilizer application rates were randomly assigned to the two treatment blocks.

5.3 STRATIFIED RANDOM DESIGN

The two treatment blocks were stratified in two different ways. Nine large grid squares (Figure 1) were established in each treatment block for the measurement of soil permeability and soil physical properties. Thirty smaller grid cells (Figure 2) were established in each treatment block for the placement of the suction lysimeters.

Figure 1. North and South treatment blocks divided into 9 squares each and randomly selected for testing of soil permeability and soil physical properties. Samples were collected in the middle of the grid square with a letter/number combination. Amounts of nitrogen applied are indicated at the bottom of the figure.

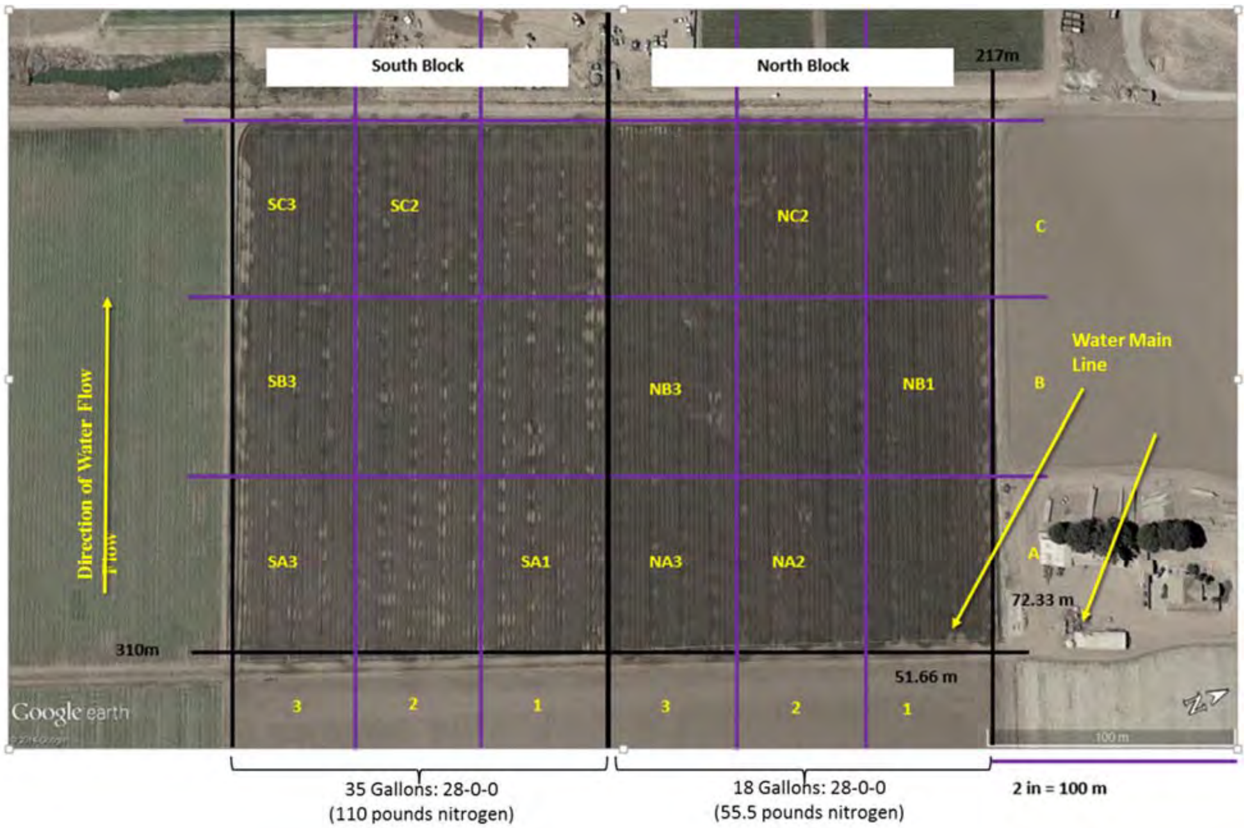


Figure 2. North and South treatment blocks gridded into 30 squares each. Lysimeters were placed within each of the gridded squares.

5.4 Soil Nitrate

Nitrate in the soil was measured to quantify residual nitrate availability to the romaine from previous crop rotations. A nine cell grid of each treatment block was created and five cells were randomly selected for soil sampling. Five soil samples each were collected from the north and the south treatment blocks prior to planting (Figure 1). The soil samples were collected at the center of each of the grid cells. A 2 ¼ inch augur was used to collect cuttings from the ground surface down to 14 inches. The cuttings from each of the holes was placed on a plastic sheet and homogenized and then placed in 4-oz glass sample jar. Samples were sent to the laboratory and analyzed for nitrate, TKN, and percent solids.

5.5 Lysimeter Installation – Depth, Density

Installation of the Irrometers occurred after pre-irrigation and planting of the romaine. A 30 cell grid was created for the north and south treatment blocks and 30 suction lysimeters were installed in each treatment block (Figure 2). The planted romaine bed that was located closest to the center of the grid cell was located and the lysimeters were installed in this bed as close to the center of the cell as possible at a depth of approximately 4 feet. They were placed approximately 12 inches from the edge of the bed and flagged so they could be seen and accessed without damaging the romaine.

5.6 Permeameter Measurements

Permeability was measured to address the spatial variability of the rate of nitrate moving past the root zone. Using the same grid system as the Irrometer installation, fifteen grid cells were randomly selected in each of the treatment blocks and permeability measurements were made near Irrometer location. Measuring permeability consisted of augering a 14 to 16 inch hole with a 2 ¼ regular auger in the romaine bed and using a Mariotte bottle style permeameter to measure the drop in head once the rate of infiltration reached a steady state. The geometry of the hole and the rate of fall was used to calculate the field saturated hydraulic conductivity.

5.7 Irrigation Water Nitrate

Irrigation water samples were collected during the study to quantify the amount of nitrate supplied by the groundwater to the field. A water sample was collected from a valve near the wellhead and from each of the risers in the field. The samples collected from the risers were collected to account for any residual nitrate from fertigation being applied to the field. In addition, a sample was collected from each of the risers while fertigation occurred to attempt to verify the fertilizer concentrations.

5.8 Sample Collection

Both the north and south treatment blocks were irrigated sequentially during the same day. The length of the irrigation sets varied, but generally lasted 3 to 4 hours. Fertigation occurred at end of the irrigation set. A single speed gas powered pump was used to inject fertilizer into drip system.

A vacuum was applied to the Irrometers in each treatment block during last hour of irrigation or as soon as fertigation began. The timing relative to the irrigation set and the order in which the vacuum was applied was the same for both treatment blocks. Samples were collected from both treatment blocks the following day in the same order the vacuum was applied. After each lysimeter was cleared and the sample collected, a vacuum was reapplied and any residual irrigation water leaching past the root zone during the subsequent five days was collected prior to the next irrigation event. Consequently, there were two samples collected during each visit to the treatment blocks. The residual irrigation sample was collected prior to the initiation of an irrigation set. Once that sample was collected, a second sample was collected representing the water leaching past the root zone during and immediately after an irrigation event.

5.8.1 Samples collected prior to irrigation event

Samples collected prior to an irrigation event from the two treatment blocks contained residual pore water from the previous irrigation. The time between the sample entering the pore water sampler and being collected for analysis was generally one week. Degradation of nitrate concentrations likely occurred during this time. However, it was likely minimal and the rate of degradation between the two treatment blocks would be similar thus allowing an accurate comparison of nitrate concentrations from these events.

5.8.2 Samples collected after irrigation

Samples collected after each irrigation event were submitted to the laboratory for analysis either the day of collection or the following day. Extraction of the samples from the Irrometers is described under Sample Collection.

5.9 Analysis of Nitrate in Samples

As with Phase I samples, all water samples collected in Phase II were analyzed for nitrate via EPA method 300.0 at Caltest Analytical Laboratory in Napa, California. To meet analytical requirements, the samples were required to be 10 mL in volume or greater, received at no more than 6 degrees Celsius, and to be analyzed within 48 hours of collection. Samples were either delivered to the laboratory or picked up by a laboratory courier after collection. The samples collected prior to the irrigation event had already been sitting in the Irrometers for up to a week prior to collection, therefore the samples collected after irrigation were analyzed first in order to meet the 48 hour hold time requirement.

5.10 Plant Tissue Nitrogen

On the day before harvest, tissue samples were collected for analysis of crude protein, total N, and moisture content. Crude protein and total N were measured as a percentage of both wet weight and dry weight. Tissue samples were separated into the harvestable fraction, and the tillage fraction. The tillage fraction is the trimmed portions of the romaine plant that are left in the field at the time of harvest. This fraction generally consists of the outer leaves and roots of the romaine plant. The tillage fraction was homogenized prior to analysis by the laboratory.

Samples were analyzed for total N using an automated combustion method performed using a Total Nitrogen Analyzer. Crude protein was determined using the Kjeldahl (TKN) method. For samples meant to reflect content by dry weight, plant material was dried over phosphorus pentoxide or magnesium perchlorate for 48 hours prior to analysis. The moisture content was determined by gravimetric loss of free water associated with heating samples to 105^{o}C for two hours. The method does not remove molecular bound water.

6 Phase II Results

6.1 Concentration of nitrate in the irrigation water

The concentration of nitrate was measured in the well on October 2, 8, and 17, 2014. In addition, the concentration of nitrate was measured on October 2, 2014 at the point of water delivery to each of the fields (4 samples). With one exception, the concentration of nitrate in the irrigation supply was relatively constant with concentrations ranging from 39 mg/L to 44 mg/L. The exception was a concentration of 160 mg/L Nitrate as N in water delivered to the south block. The concentrations measured at the wellhead were 38 mg/L, 39 mg/L and 51 mg/L (Table 3).

Table 3. Irrigation water nitrate concentrations measured at the well head.

Sample Date	Nitrate as N (mg/L) – Well Head	Nitrate as N (mg/L) – Point of Water Delivery
02/Oct/2014	38	43, 44, 39, 160
08/Oct/2014	39	-
17/Oct/2014	51	-
Average	**42.6**	**71.5**

6.2 SPATIAL VARIATION IN K_{SAT}

Saturated hydraulic conductivity calculated for the sample locations varied considerably across both fields (Table 4). The hydraulic conductivity of the soil in both fields is relatively high but the average calculated value in the north field is 2.25 times higher than for the south field. The variability of the recharge in the north field, as measured by the standard deviation of the K_{sat} values, is three times greater than in the south field. These values indicate that although there were what appeared to be slight differences in soils between the treatment blocks, those differences resulted in relatively significant large differences in the saturated hydraulic conductivity.

Table 4. Saturated hydraulic conductivity for both the north and south fields. The north field received half the fertilizer of the south field.

	North K_{sat} (cm/sec)	South K_{sat} (cm/sec)
Average K_{sat}	0.0027 (15)	0.0012 (13)
St Dev.	0.0033	0.0011

6.3 SOIL CHEMISTRY

There was no difference in the concentration of nitrate in the soil of the two treatment blocks (Table 3). The maximum concentration was similar in both treatment blocks, and the minimum concentration was slightly lower in the south block. However, the variability in nitrate concentration was about the same in both fields. Consequently, both fields were planted with the same baseline amount of nitrate available in the soil.

The amount of organic nitrogen (TKN) in the soil was significantly different in the two fields (Table 5), primarily as a result of a single sample from the south field. If that single sample is removed from the data, the average concentration of TKN in the south field is only 593 mg/kg which is slightly lower than the concentration in the north field. The single sample with the elevated concentration of TKN could have been the result of a small amount of plant material collected from the soil profile.

Table 5. Concentration of nitrate and TKN in soil prior to planting. The outlier is not included in the calculations for the table.

	Nitrate in Soil (mg/kg Nitrate as N) North Block	TKN in Soil (mg/kg) North Block	Nitrate in Soil (mg/kg Nitrate as N) South Block	TKN in Soil (mg/kg) South Block
Average	27	648	22	593
St Dev	9.9	58.9	11.7	40.1

The first lysimeter samples (September 24, 2014) collected water from the sprinklers that infiltrated through the soil profile to below the root zone. These samples represent the amount of nitrate leaving the root zone prior to any fertilizer applications (Table 6). A majority of the water applied by the sprinklers had left the soil profile before sampling resulting in 12 samples collected from the north block and 3 samples from the south block.

Although there were small differences in the amount of nitrate or organic nitrogen in the soil prior to planting, samples in the first lysimeter sample on September 24 showed the largest differences between treatment blocks. By the next day after the first drip irrigation/fertigation event the concentration of nitrate in the lysimeters in the two treatment blocks were much more similar. From that point through harvest, the concentration of nitrate in the south (110 lbs/acre) treatment block was between 57% and 85% of the concentration in the north treatment block (55 lbs/acre). I.e. the lower application rate in the north treatment block resulted in the greater leaching of nitrate past the root zone. There was no relationship between the absolute concentration of nitrate in either block and the percent difference in average concentration between the two blocks. I.e. higher concentrations of nitrate in the north block did not result in a larger percent difference between the two blocks.

Soils in both fields are Chualar Loam with a moderately high K_{sat} (0.2 – 0.57 inches/hr [0.000141 cm/sec – 0.00040 cm/sec]). However, variation in permeability on a local level is significant leading to a significant difference in the amount of nitrate leaching past the root zone on the two fields.

Table 6. Percentage of the nitrate concentration in the north field relative to the concentration in the south field. The potential number of samples that could have been collected from each treatment block was 30.

Sample Date	Number of North Block Samples	Number of South Block Samples	South Block Nitrate Concentration as a Percentage of the North Block
9/24/2014	12	3	14.8
9/25/2014	23	23	45.6
10/2/2014	29	26	63.2
10/3/2014	27	30	57.0
10/8/2014	26	28	73.6
10/9/2014	28	30	85.3
10/17/2014	30	26	83.8
10/18/2014	21	25	62.9
10/23/2014	23	27	71.1
10/24/2014	26	22	65.8
10/27/2014	26	25	76.4
		Average	**63.6**

6.4 NITROGEN IN LETTUCE

The treatment blocks did not differ in any crude protein (as a percentage of wet or dry weight), total N (as a percentage of wet or dry weight), or moisture content in either harvested material or the tillage fraction (Table 7). Therefore, differences in fertilizer application rate were not reflected the nitrogen content of the plant tissue harvested or left in the field.

Table 7. Nitrogen and moisture content of harvested and tillage plant tissue from both treatment blocks. Plant tissue was collected on the day prior to harvest (n=10).

Treatment Block	Type of Plant Tissue	Crude Protein (% DW)	Crude Protein (% WW)	Total N (% DW)	Total N (% WW)	Moisture Content
North	Harvested	23.5	1.3	3.76	0.22	94.3
South	Harvested	23.8	1.3	3.81	0.20	94.7
North	Tillage	19.0	1.1	3.04	0.17	94.2
South	Tillage	19.3	1.1	3.09	0.18	94.0

7 Phase II Discussion

Samples were collected during every irrigation event on both treatment blocks. Of the 30 lysimeters installed on each treatment block, samples were collected from 21 to 30 lysimeters. Again, as in Phase I, the suction lysimeters appeared to be perfectly suitable for sampling nitrate below the root zone.

In this field trial, one of the treatment blocks (South) received the recommended amount of nitrogen fertilizer. The management practice imposed on the other treatment block (North) was the application of one-half of the recommended amount of fertilizer. Applications on the blocks occurred sequentially although both blocks were fertilized within a few hours of each other. All other management practices were identical on both treatment blocks.

Consistently, the treatment block with the high application rate (South) had reduced leaching past root zone. For all sampling events, the average concentration of nitrate was higher in the North block than the South block. The range of concentrations across each treatment block was large and the larger amount of nitrate leaching in the North block was primarily a result of some extremely large concentrations in some samples.

The outcome of the field trial is different from the expectation. It was expected that the treatment block that had less nitrogen applied would have lower concentrations of nitrate in the pore water collected from the lysimeters; the data indicate that the opposite occurred in this trial. The potential reasons for the difference include: 1) significantly larger amount of residual nitrogen in the soil in the North treatment block compared to the South block, 2) significantly larger amounts of nitrogen incorporated into plant tissue in the South block which leaves less nitrogen available for leaching, or 3) differences in hydraulic conductivity between the treatment blocks resulting in larger amounts of nitrogen being lost in the North block.

Prior to planting, there were no differences between blocks in the amount of organic nitrogen or nitrate in the soil. There is no evidence to indicate that the additional nitrate moving past the root zone in the North block is a result of a larger initial pool of nitrogen in the soil profile. CDFA (http://apps.cdfa.ca.gov/frep/docs/Lettuce.html) reports that the optimal application rate of N for summer/fall lettuce is 100 – 140 lbs/acre suggesting that the amount of N applied was not excessively large. At harvest, the nitrogen content of lettuce on both sides was the same. Consequently, the greater percentage concentration is not a result of larger amounts of nitrogen being incorporated into plant tissue in the South block.

It is possible that the larger amount of nitrogen incorporated into tissue in the South block was a result of a larger yield in the South block. Yields in both blocks were not tracked separately. However, the cooperating grower did not notice a difference in yield and the combined yield of the two blocks was the highest yielding field compared to 14 other fields harvested between September and November.

There were differences between the two treatment blocks in hydraulic conductivity. Hydraulic conductivity in the North block was approximately 2 – 3 times greater than on the South block. The difference in hydraulic conductivity is impossible to translate to a difference in the relative uptake of nitrate, but clearly there existed a significant difference in the amount of nitrate leaching past the root zone between blocks. The interesting conclusion from these data is that hydraulic conductivity is more important than nitrogen application rate in determining potential losses through the root zone.

The objective of this study is to determine if suction lysimeters can be effective in determining if differences in leaching rates of nitrate could be detected when management practices differ between fields. This field trial clearly indicates that differences can be detected, even if those differences are contrary to expectation. However, it is also clear that additional measurements of the physical and chemical properties of the soil, e.g. permeability, must be made before the measured concentrations can be placed into context.

Several conclusions arise from this study.

Conclusion 1: Thirty lysimeters distributed over 8.35 acres (1 lysimeter per 0.27 acres) is sufficient to collect enough samples to detect differences in the management practices used in this field trial.

The number of lysimeters deployed for this study was based on the assumption that each sampling event would result in fewer samples that were collected. The cost of the lysimeters and their deployment is small relative to the cost of nitrate analysis. The large number of samples resulted in a substantial analytical cost. For studies with a smaller budget for nitrate analyses, the minimum sample size needed to detect differences between blocks is of interest. Additional analysis needs to be performed to determine the minimum number of lysimeters that could be deployed and still detect a difference between treatment blocks.

Conclusion 2: The data developed in this study were sufficient to determine a difference in the concentration of nitrate between the two treatment blocks.

Although the one lysimeter per 0.27 acres provided enough data to determine difference, this was mostly due to an 81% success rate of collecting a sample. Future studies should evaluate the minimum sample size necessary in order to determine a difference between treatments.

Conclusion 3: Additional soil parameters should be measured.

Permeability of the soil on a relatively fine scale appears to play a significant role in determining the rate at which nitrate moves through the soil profile. To fully understand the results of any study using lysimeters, permeability of the soil needs to be measured.

Management Practices Effectiveness Program

MPEP

Management Practice Effectiveness Program

Confirm that management practices implemented to improve groundwater quality are working

Are agricultural management practices protective of groundwater?

Modify practices if needed

Implemented by CV Coalitions either individually or combined effort

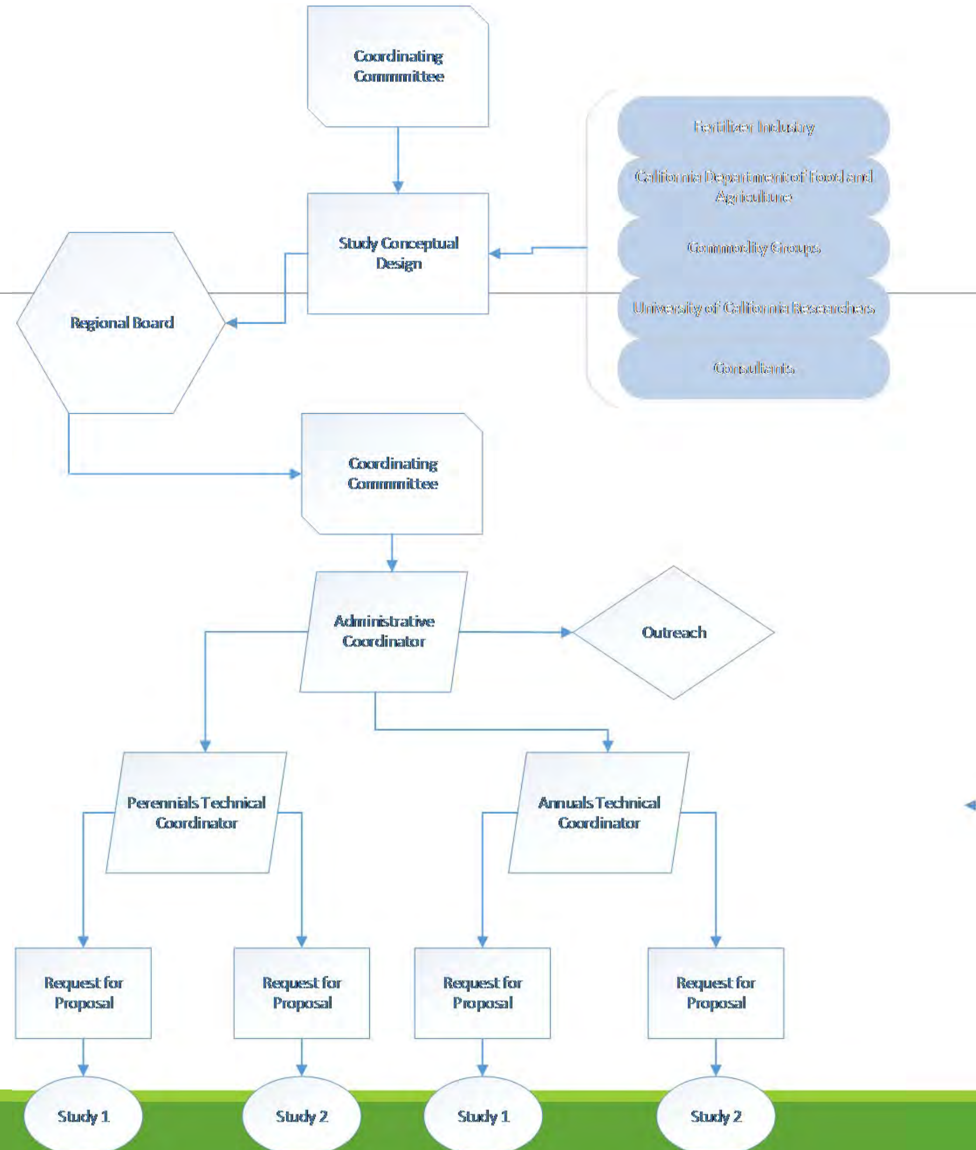
Coordinated effort by coalitions/commodity groups to complete

Share study expenses among coalitions willing to collaborate

MPEP Study Objectives

1. Identify whether site-specific and/or community-specific management practices are protective of groundwater quality within high vulnerability groundwater areas
2. Determine if newly implemented management practices are improving or may result in improving groundwater quality
3. Develop an estimate of the effect of Member's discharge of constituents of concern on groundwater quality in high vulnerability areas. A mass balance and conceptual model of the transport, storage, and degradation/chemical transformation mechanisms for the constituents of concern or equivalent method approved by the Executive Officer
4. Utilize the results of evaluated management practices to determine whether practices implemented at represented Member farms (i.e., those not specifically evaluated, but having similar site conditions), need to be improved.

MPEP Process Flow Chart



2012 Specialty Crop Block Grant – Field Tour

CURES

JUNE 16, 2015

Project Goal

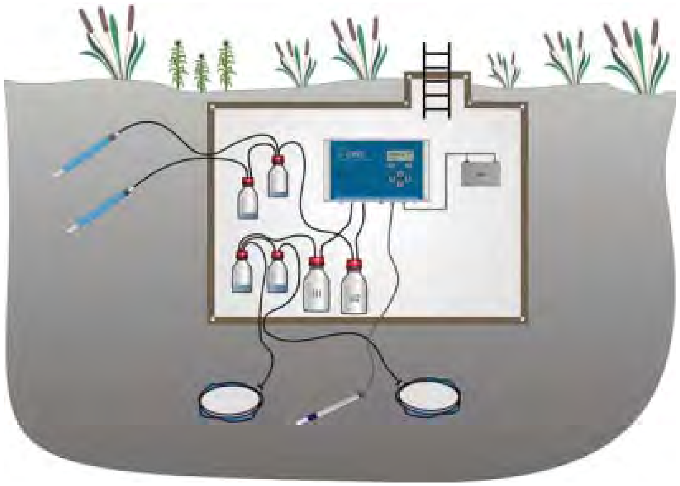
The project's goal is to establish one or more reliable, repeatable scientific methods to characterize movement of nitrogen fertilizers beyond the plant root zone in walnuts and broccoli/lettuce, and, ultimately, in many of the specialty crops grown in the Central Valley and Central Coast.

Methods – Automated Lysimters (UMS)

A UMS is composed of a water-tight box containing a battery, pump and sample bottles which are attached via cables and tubing to a tensiometer and two ceramic cups with pores buried in the soil matrix. The ceramic cups are buried at two depths (4ft and 7ft) to collect samples above and below the root zone.

The tensiometer measures the water content of the soil and when the soil is sufficiently wet, a signal is sent to the pump to pull a sample from the soil surrounding the ceramic sampling cups. The sample is pulled from the ceramic cups to the sample bottles located in the box. Samples from the bottles are sent to the laboratory for analysis.

The diagram to the right shows how a VS system might be set up. Disregard the leachate plates, as they are not part of this study.



Methods – Manual Suction Lysimeters (Irrometers)

The second system consists of manual suction lysimeters placed above and below the root zone, at the same depths of the UMS system. During site visits, the suction lysimeter is placed under a vacuum pulling water from the surrounding soil into the ceramic container and into a sample bottle on the surface.

2013 Studies

4 Areas / Crops

Compared UMS vs Lysimeter methodology

Two sampling systems are employed at each location – an automated Underground Monitoring System (UMS) and a suction lysimeter system. For each location there is one UMS and three (3) suction lysimeter systems.

Evaluated collection success and nitrate concentrations

- Stockton – Walnuts
- Salinas – Lettuce
- Gonzales – Lettuce / Cauliflower
- Santa Maria - Lettuce

CDFA Trial – Example of Study Design

	Stockton	Salinas	Gonzales	Santa Maria
Crop	Chandler Walnuts	Romaine Lettuce	Romaine Lettuce Cauliflower	Romaine Lettuce
Soil Type	Boggiano Clay Loam	Chualar Loam	Mocho Silt Loam	Tujunga Loamy Sand
Capacity of the most limiting layer to transmit water (Ksat (in/hr):	Very low (0.0)	Moderately high (0.2-0.57)	Moderately high to high (0.57-1.98)	High to very high (5.95-19.98)
UMS Automated Samplers				
Number of sets	1	1	1	1
Depths (ft)	4, 7	4, 8	4, 8	4, 8
Target Suction (kPa)	67, 67 **	40, 55	25.5, 54.6	60, 60
Irrometer Manual Samplers				
Number of sets	3	3	3	3
Depths (ft)	4, 6	2, 4	2, 4	2, 4
Target Suction (kPa)	50, 75	50, 75	50, 75	50,75
Date Range (2013)	July - December	June -December	July -December	August - December
Number of Visits	7	13	9	10
Number of Installations	1	3	2	2
Number of Samples	4	38	15	16
Depth to Water Table (feet)	97 to 150	197-292	62-72	52-70

*Ksat is a measure of the capacity of a saturated soil to transmit water. These figures are for the most limiting layer in the top meter of soil, from the Web Soil Survey.

**The vacuum pump at the Stockton orchard is Tensiometer controlled so that the vacuum pum turns off if soil at 3.7' is less moist than -40 kPa, but maintains a suction of the current tensiometer reading minus 27.2 kPa if the tensiometer reads a soil water potential more positive than -40 kPa.

Instrumentation

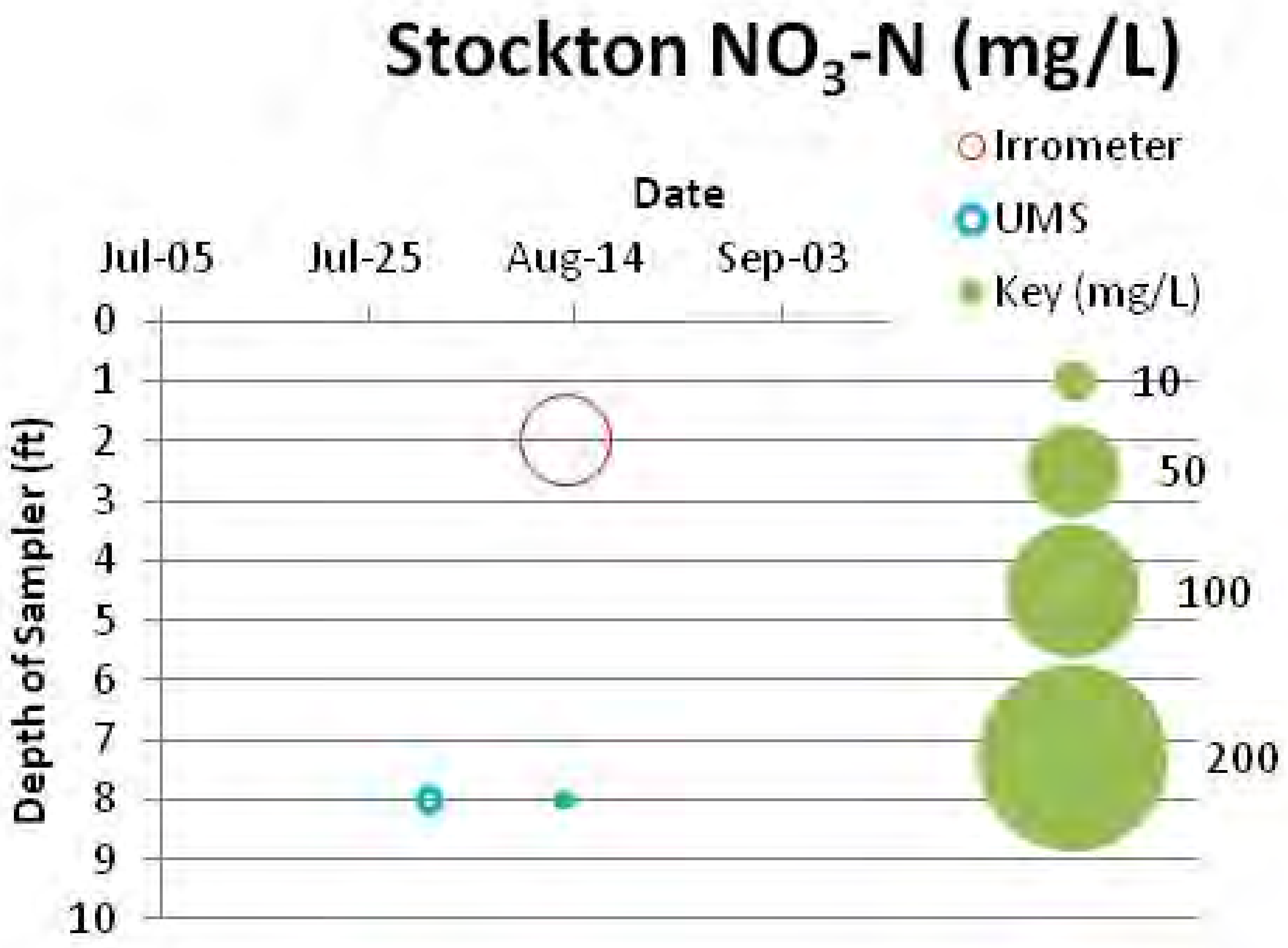
UMS sampling

2013 - Methodology Comparison Summaries

Stockton - Walnuts

- Tensiometer placed at 3.7 ft
- Irrometers placed in-line with tree rows on either side of trunk
- Few samples were collected (4 total)
- When installing the UMS and Irrometers, the crews found an impermeable clay layer at 5 ft that may be affecting sample collection. The shallow Irrometers have had difficulties holding suction.
- The Irrometer samples collected at a shallow depth had a higher average nitrate concentration than the deep samples collected with the UMS

Stockton nitrate concentrations. Area of circular symbols represents averaged nitrate concentrations if more than one sample was collected at the same depth from the Irrometer depth on the same day. The larger the circle, the greater the concentration of nitrate (green circles are a key for the size ranges).



Salinas - Lettuce

Tensiometer placed at 2 feet

Irrometers placed in-line with lettuce on either side

Samples were consistently collected in both the UMS and Irrometer sets

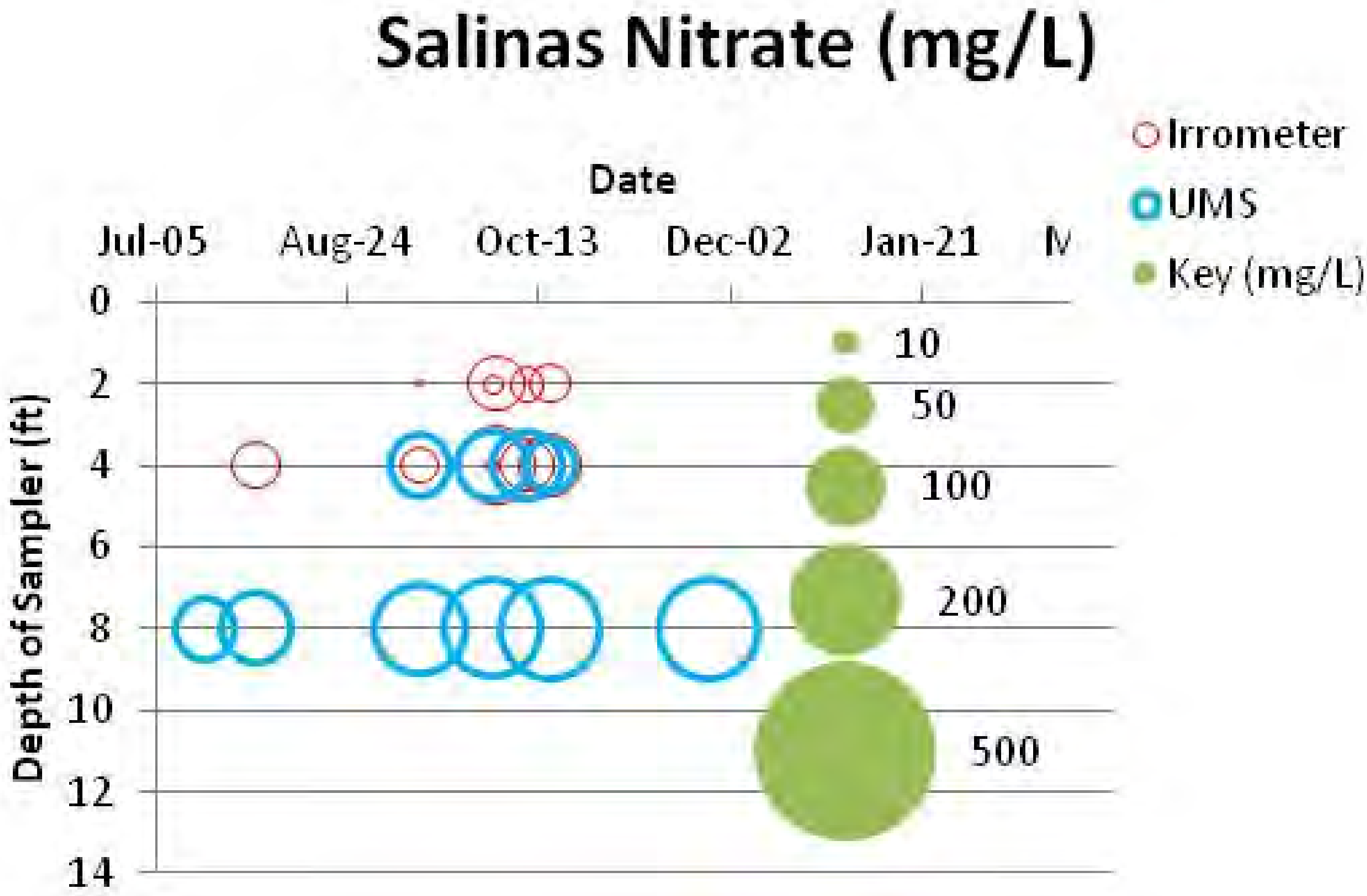
At 2 feet, the soil has been consistently moist allowing for consistent sampling

There were 10 sets of samples that were collected in both the shallow and deep across 5 dates; 8 of the sets had higher concentrations of nitrate in the deep samples versus the shallow samples.

Salinas nitrate concentrations.

Area of circular symbols represents averaged nitrate concentrations if more than one sample was collected at the same depth from the Irrometer depth on the same day.

The larger the circle, the greater the concentration of nitrate (green circles are a key for the size ranges).



Gonzales – Lettuce / Cauliflower

Tensiometer placed at 2 feet

Irrometers placed in-line with cauliflower on either side

Few samples were collected (4 total)

Shallow soil has more variability in moisture than the deeper soil which makes sample collection difficult

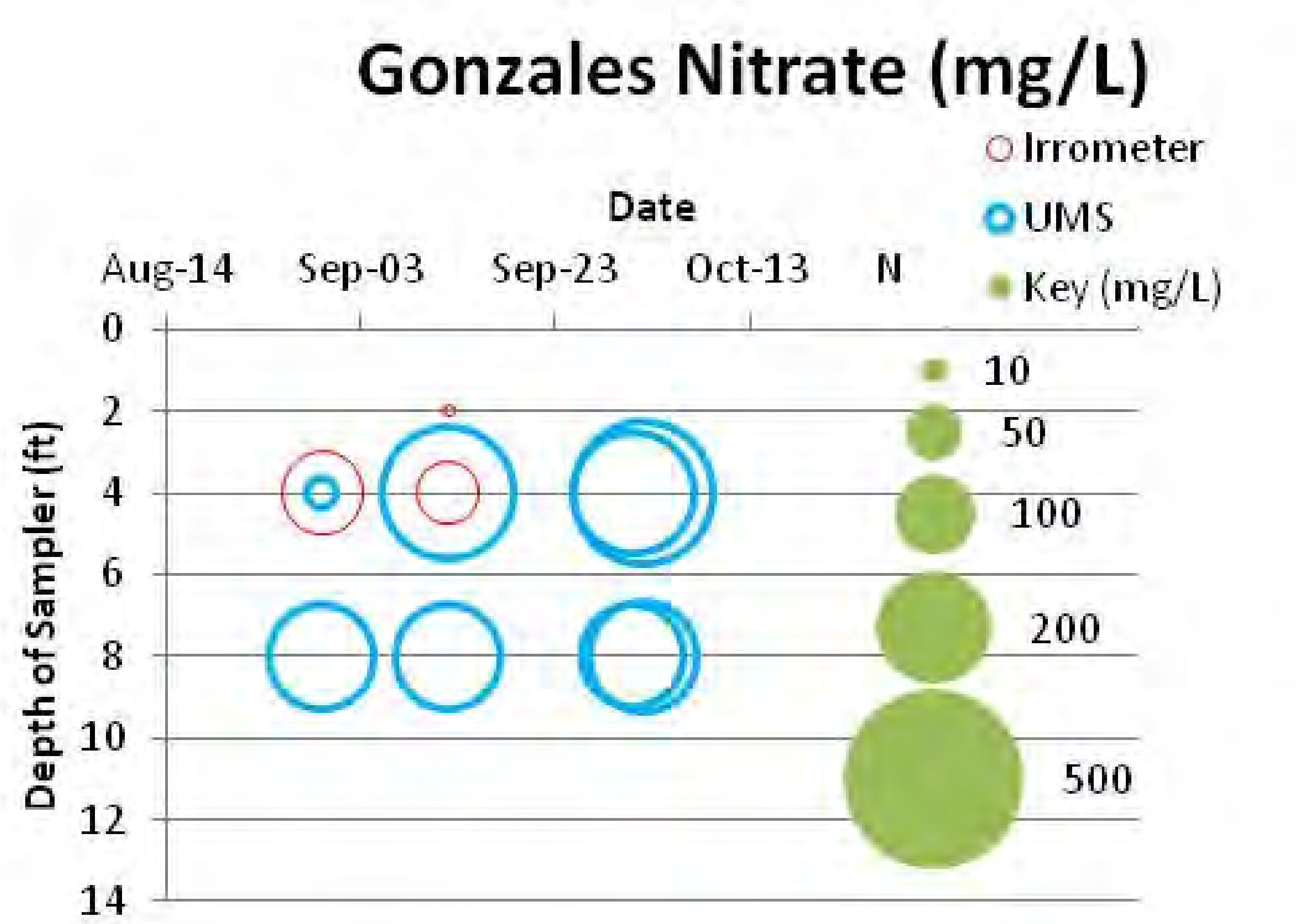
Typical water content tends to be just below field capacity

The Irrometer samplers were less consistent in collecting samples than the UMS sampler which may be due to the more consistent soil moisture at deeper depths

Gonzales nitrate concentrations.

Area of circular symbols represents averaged nitrate concentrations if more than one sample was collected at the same depth from the Irrometer depth on the same day.

The larger the circle, the greater the concentration of nitrate (green circles are a key for the size ranges).



Santa Maria - Lettuce

Tensiometer placed at just under 2 ft

Irrometers placed in-line with lettuce on either side

Samples were collected consistently in both the UMS and Irrometer sets

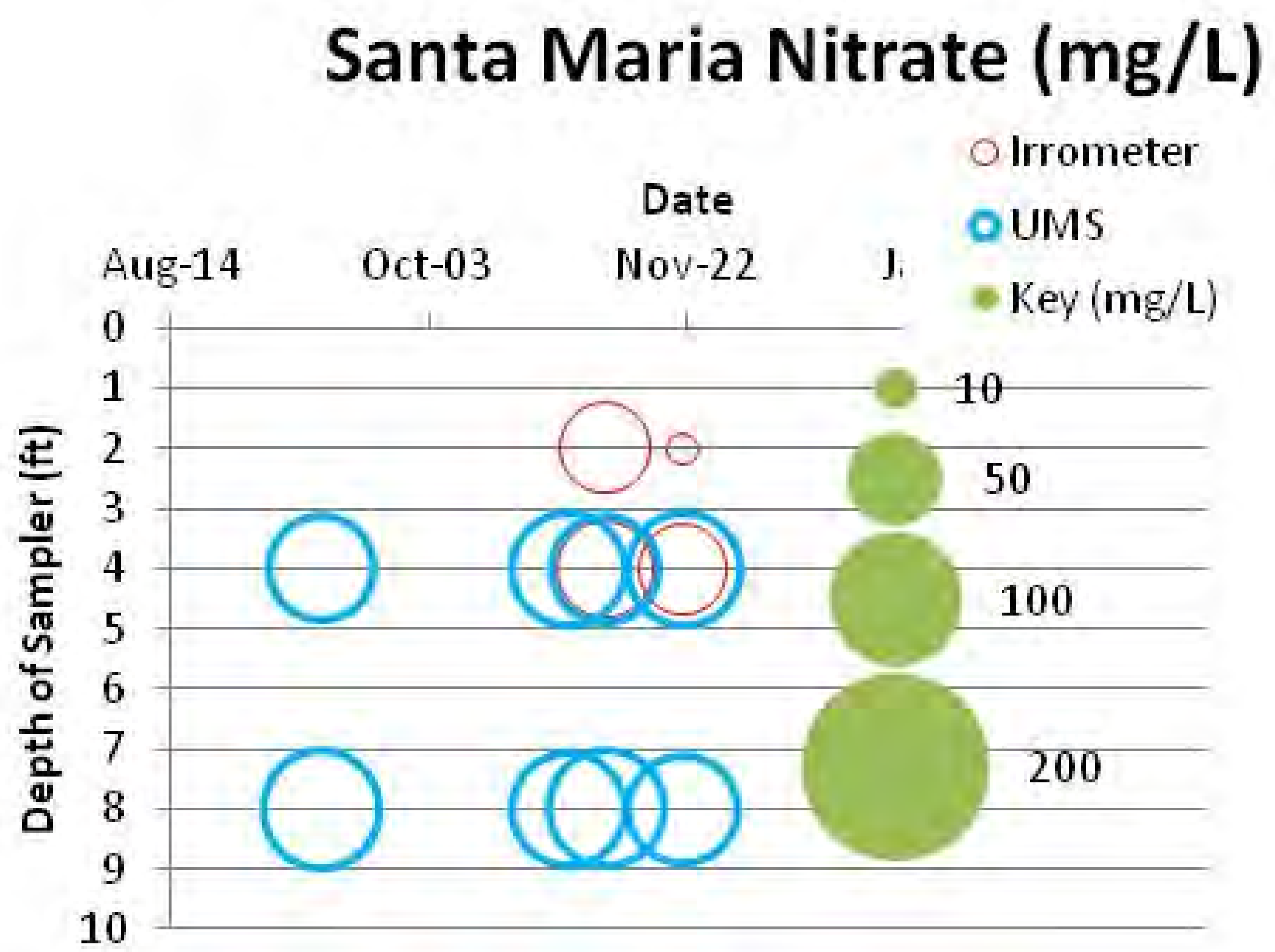
The nitrate concentrations from samples collected by the UMS were very consistent between the shallow and deep samples collected at the same time.

The Irrometer and UMS samples collected at the same depth and time have similar nitrate concentrations.

Santa Maria nitrate concentrations.

Area of circular symbols represents averaged nitrate concentrations if more than one sample was collected at the same depth from the Irrometer depth on the same day.

The larger the circle, the greater the concentration of nitrate (green circles are a key for the size ranges).



Site	Date	Nitrate Concentration (mg/L)							
		UMS		Irrometer Set 1		Irrometer Set 2		Irrometer Set 3	
		Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
Gonzales	8/30/2013	13	170		100		72		130
	9/12/2013	267.9	170		35		4.2	1.8	130
	10/1/2013	230	160						
	10/2/2013	300	180						
Salinas	7/18/2013		56						
	7/31/2013		76						
	8/30/2013			6.8		6.9	20	29	50
	9/12/2013	56	121			0.21	0.66		39
	10/1/2013	72	140	5.7		5.6	3.5		0.87
	10/2/2013			95		27	100	16	94
	10/10/2013	71		27	13	9.2	47		70
	10/16/2013	42	150	28	5.9	3.3	58	3.5	110
	11/26/2013		150						
Santa Maria	9/12/2013	60	75						
	10/30/2013	70	70						
	11/6/2013	62	74		28		87	45	43
	11/21/2013	70	65		29		68	5.7	36
Stockton	7/31/2013		5.9						
	8/13/2013		1	0.046				90	

2014

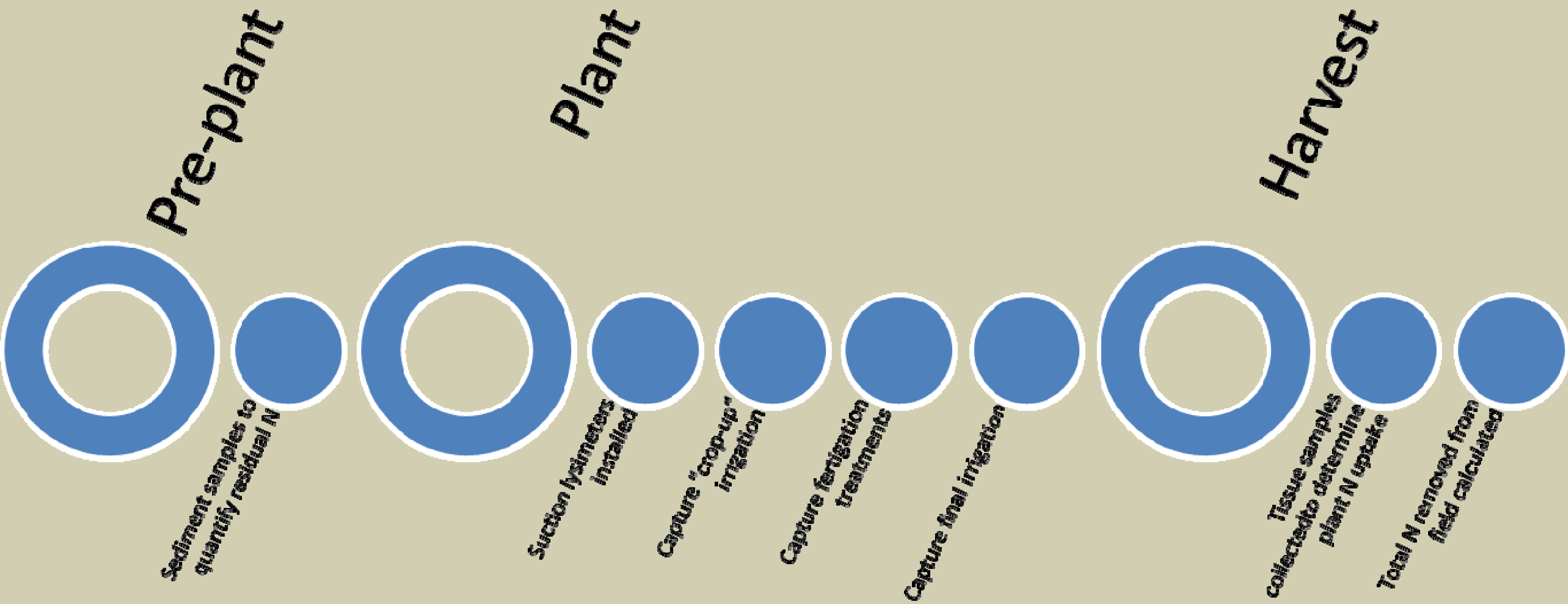
Romaine Field Trial

Salinas, CA

Utilization of Irrometer methodology to measure difference in nitrogen concentration in fields with different nitrogen management practices.

Study Design: Suction lysimeters are located within each grid square

- 60 total lysimeters
- Total acreage = 16.7 acres (8.35 acres per block)
- White font indicates permeability measurement location



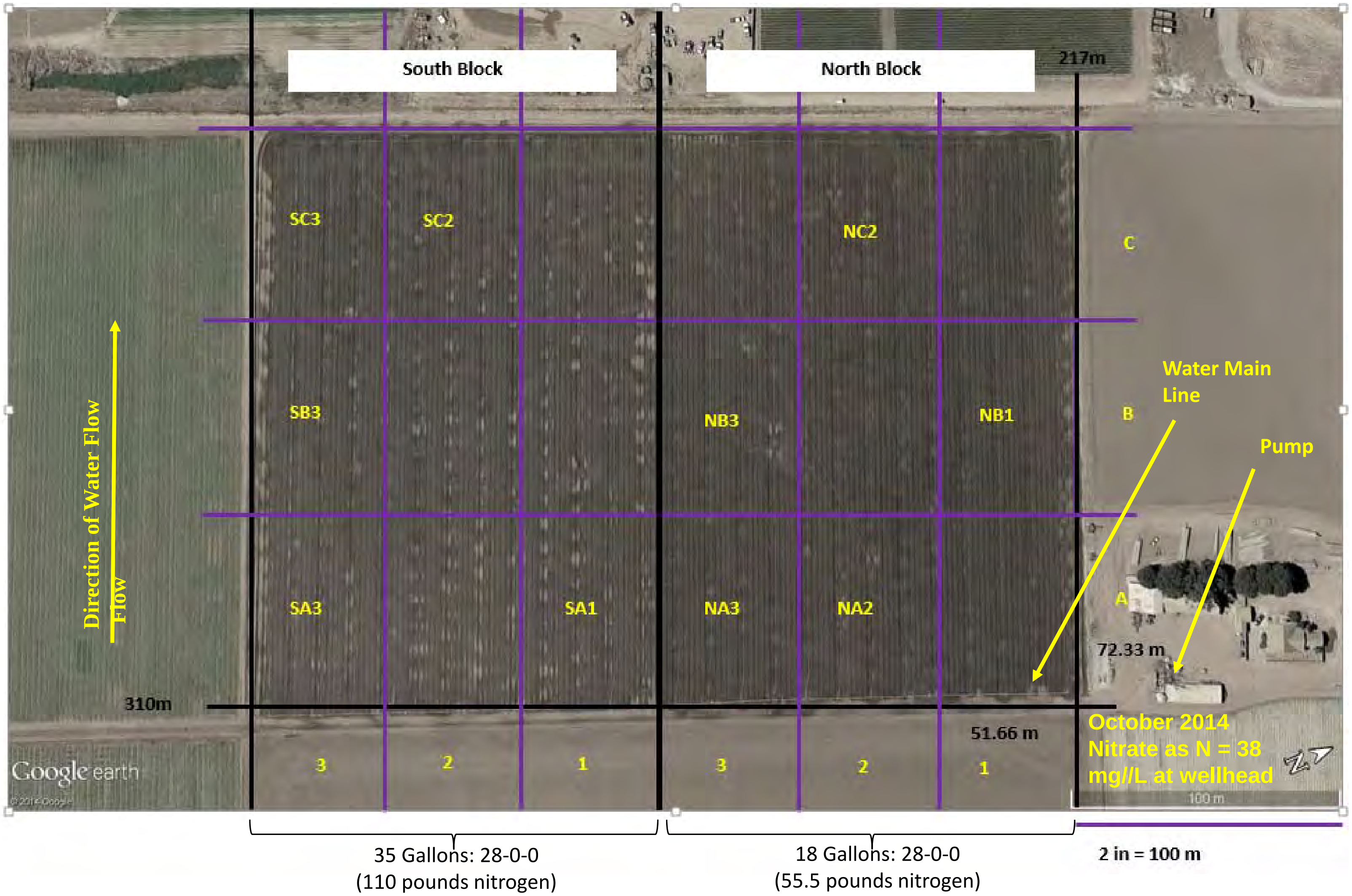
Lettuce Trial - Timeline

Samples: soil, irrigation water, pore water, crop/tissue

Instrumentation:

Installation of suction lysimeters. A pilot hole is created by driving a rod into the soil; a lysimeter (on ground) is then installed.

Permeability measurements: measures the rate of water infiltration through the soil; important to know when determining the movement of water (and nitrogen fertilizers) through the soil



Soil sampling grid and soil sampling locations

Pre-plant Concentration of Nitrate and Organic Nitrogen in the Two Fields

North 55 lbs	Concentration (mg/kg Nitrate as N)	TKN (mg/kg)	South 110 lbs	Concentration (mg/kg Nitrate as N)	TKN (mg/kg)
Average	27	648		22	795
St Dev	9.9	58.9		11.7	405.0

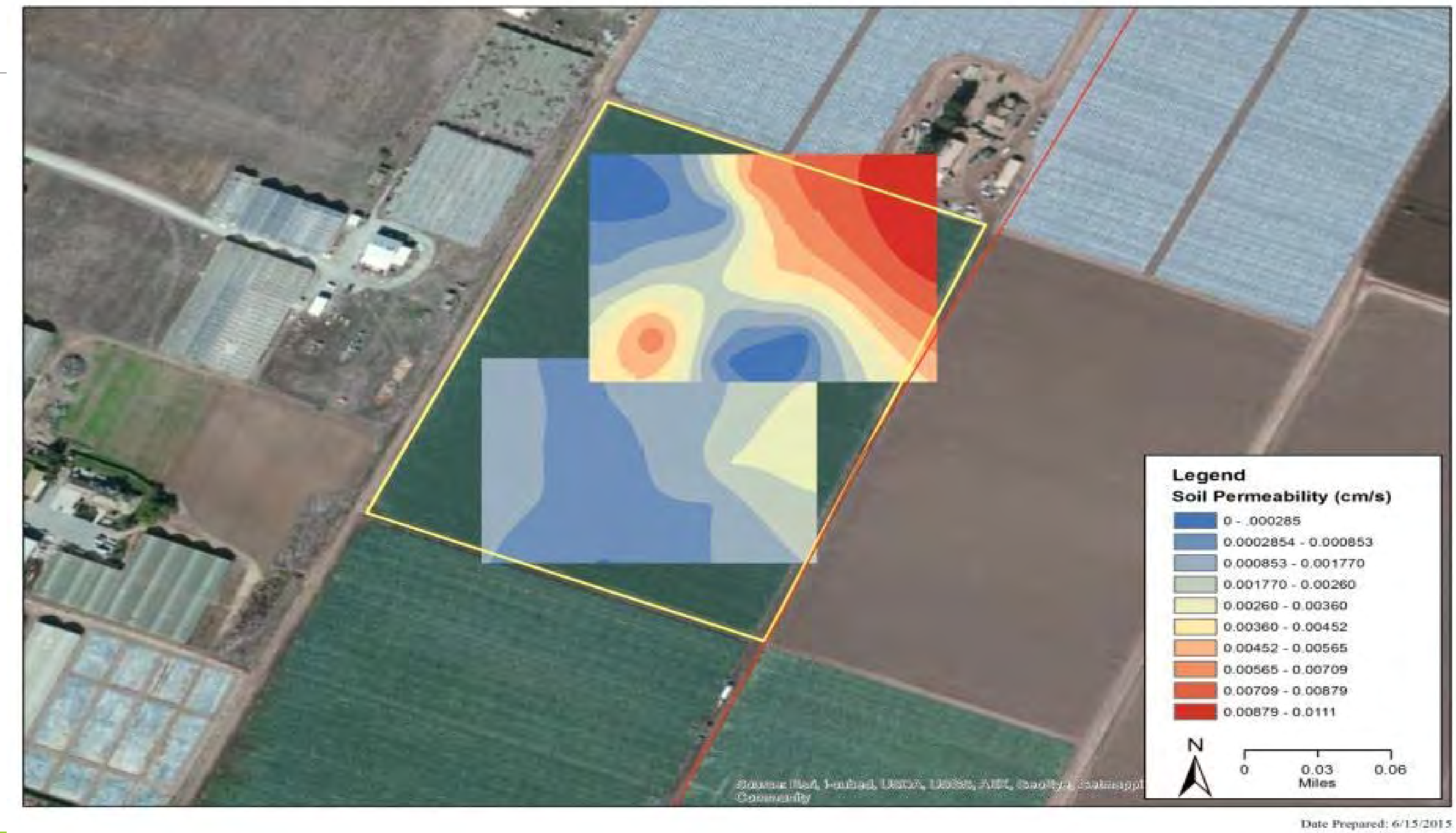
Concentration of Nitrate in Well Water

Date	Location	Concentration (mg/L Nitrate as N)
08/Oct/2014	IRR-WELL	39
17/Oct/2014	IRR-WELL	51

Permeability of the Two Fields

	North Field K_{sat} (cm/sec)	South Field K_{sat} (cm/sec)
Average	0.0027	0.0012
St Dev.	0.0033	0.0011

Soil Permeability

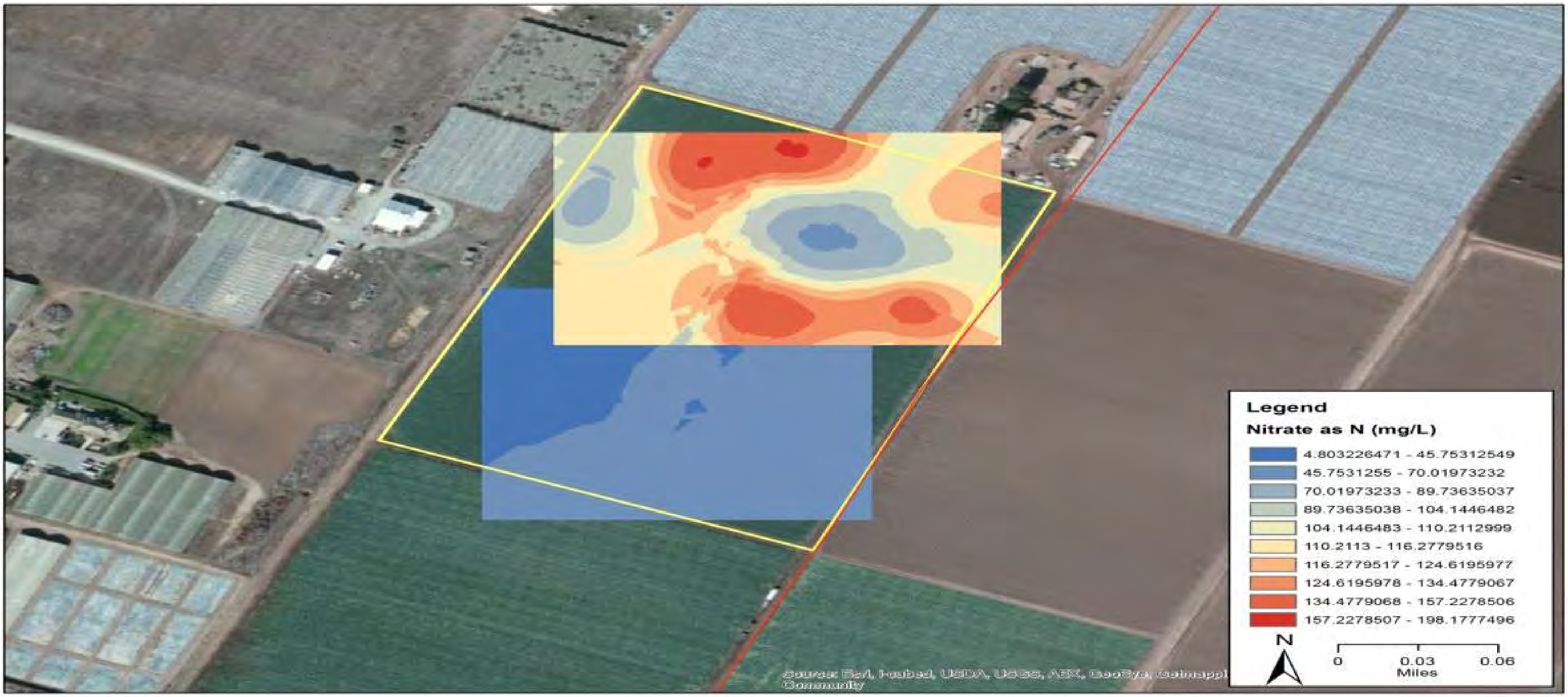


Concentration of Nitrate Below the Root Zone

Date	Field (55 lbs)	Average	Range	N	Field (110 lbs)	Average	Range	N
9/24	N	104.7	6.6 - 190	12	S	15.5	7.5 - 28	3
9/25	N	116.4	17 - 220	23	S	53.07	0.42 - 160	23
10/2	N	106.7	0.35 - 420	29	S	67.4	0.11 - 180	26
10/3	N	153.1	85 - 270	27	S	87.3	0.23 - 220	30
10/27	N	105.9	1.3 - 200	26	S	80.9	2 - 190	25

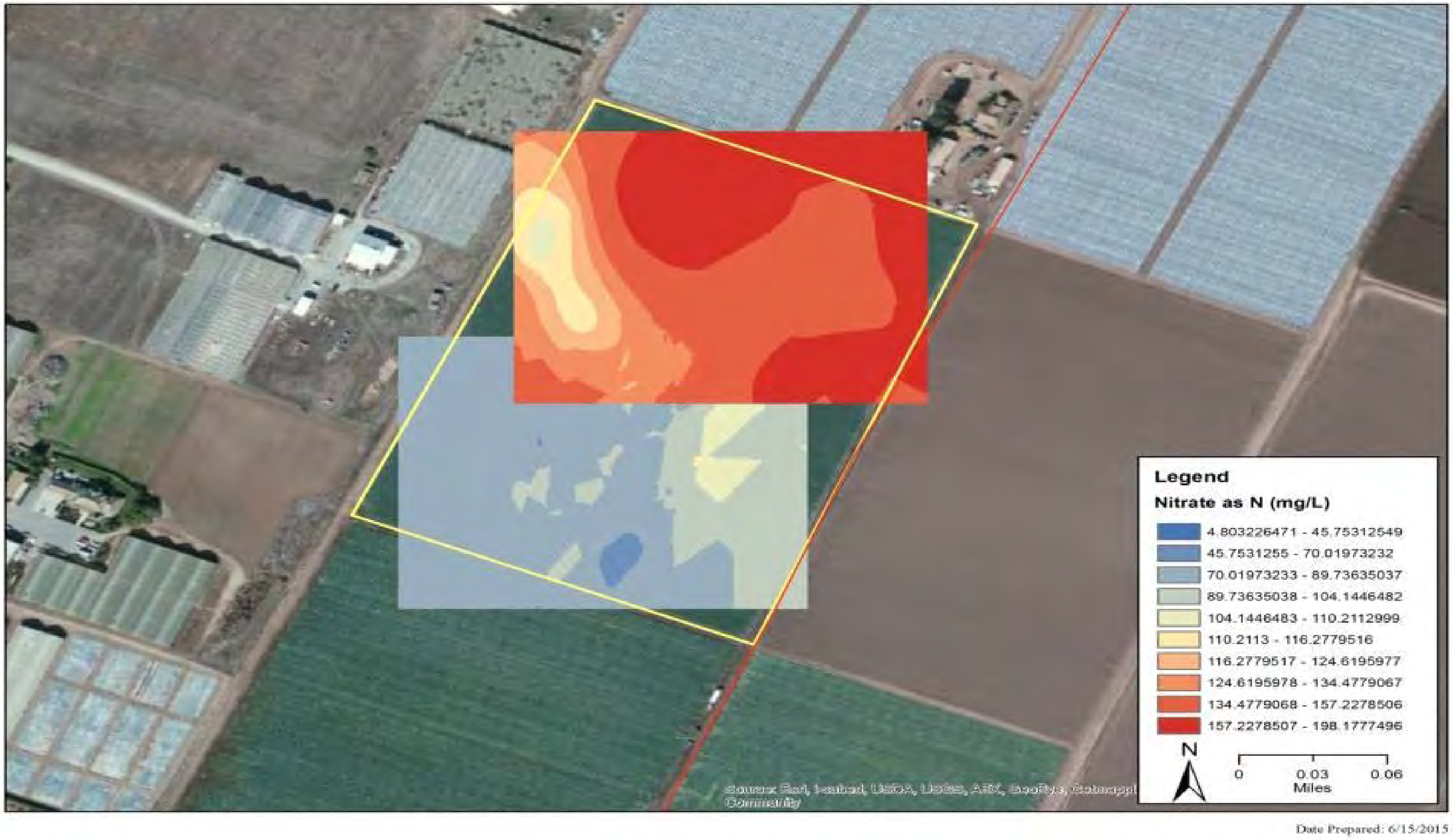
Nitrate Concentration Below the Root Zone

September 25, 2014

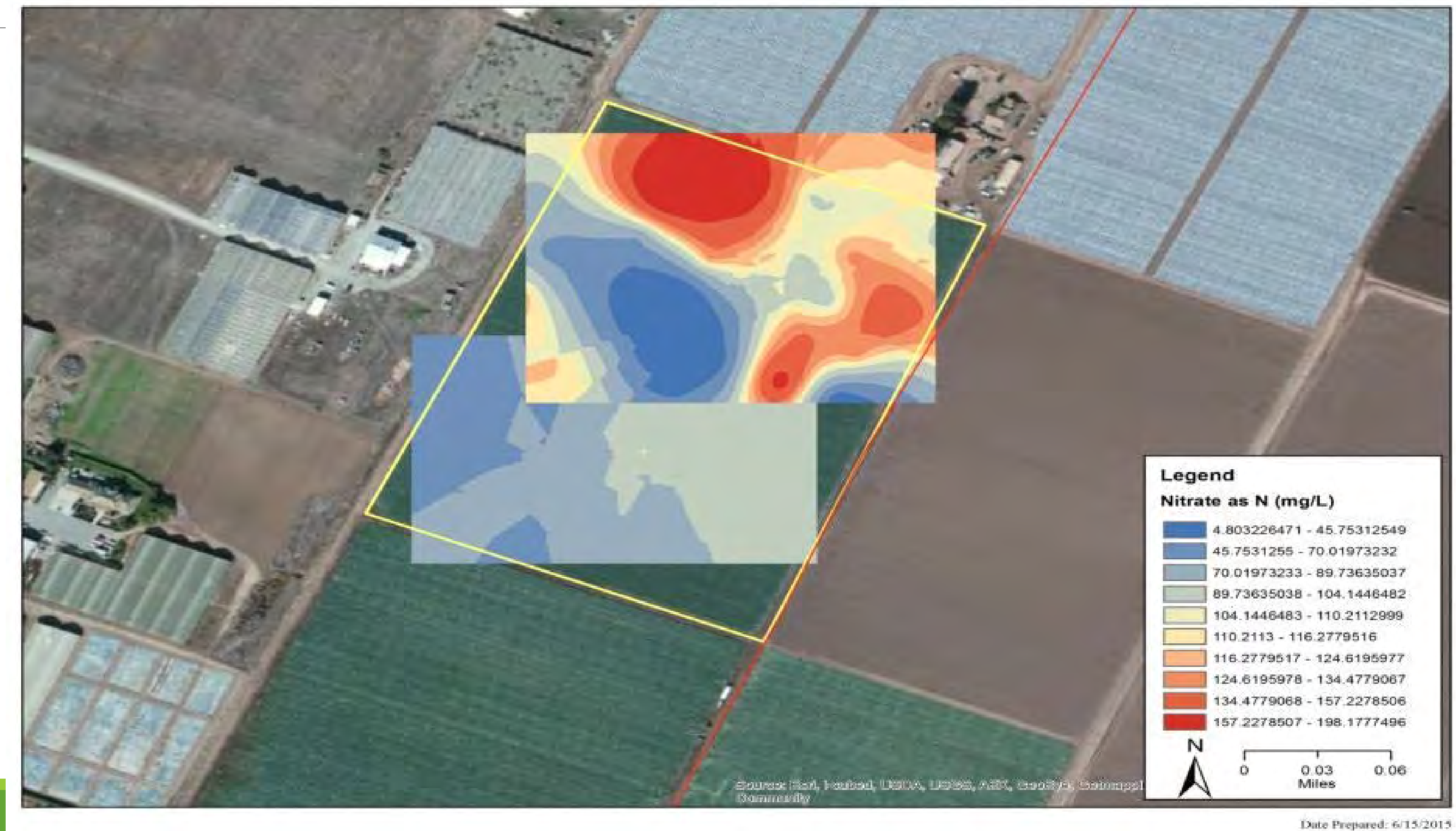


Date Prepared: 6/15/2015

Nitrate Concentration Below the Root Zone
October 3, 2014



Concentration of Nitrate Below the Root Zone at Harvest



Results of Lettuce Field Trial

- The fields did not differ in the amount of nitrate present in the soil prior to planting. Any differences in nitrate leaching past the root zone were the result of nitrate applied during the crop cycle.
- The two sections of the field differed significantly in the permeability with one section of the field being twice as permeable as the other. The side of the field that received the least nitrate had the highest permeability with some locations having extremely high permeability.
- A significant amount of nitrate leached past the root zone in each section with the concentration in water collected from the lysimeters ranging from 50 mg/L to 150 mg/L depending on the date collected.
- The section of the field with the lowest application rate of nitrate and the highest permeability had approximately twice the amount of nitrate leaching past the root zone. Although the amount of nitrate leaching past the root zone varied from week to week, there was consistently about twice the nitrate in the lysimeters from the high permeability/low nitrate application section compared to the low permeability/high nitrate application section.
- There were no differences in the moisture content, crude protein, or total N content of the trimmed tissue or the Romaine head between the two sides. Mass of Romaine tissue harvested from each section individually was not available so it is not possible to determine if total tissue nitrogen content was different between the two sections.

Hartz (2007) reported that with a concentration of nitrate in soil that is greater than 20 PPM (mg/kg), there is adequate nitrate in the soil to support crop growth for at least several weeks and additional N fertilization can be delayed or even eliminated.

Hartz (2007) reported that with a concentration of nitrate in soil that is greater than 20 PPM (mg/kg), there is adequate nitrate in the soil to support crop growth for at least several weeks and additional N fertilization can be delayed or even eliminated.

Top Issues of the Day

CENTRAL COAST GROUNDWATER COALITION

Sampling Stats as of 6/16/15					
	Domestic	Percent	Irrigation	Percent	Total
WELL WITH EXCEEDANCES					
Monterey	134	97%	4	3%	138
San Benito	13	100%		0%	13
San Luis Obispo	22	25%	65	75%	87
Santa Barbara	28	22%	98	78%	126
Santa Clara	24	89%	3	11%	27
Santa Cruz	10	71%	4	29%	14
Ventura	0	0%	0	0%	0
TOTAL	231	57%	174	43%	405
TOTAL WELLS					
Monterey	260	96%	10	4%	270
San Benito	64	97%	2	3%	66
San Luis Obispo	93	42%	127	58%	220
Santa Barbara	121	30%	281	70%	402
Santa Clara	92	96%	4	4%	96
Santa Cruz	57	85%	10	15%	67
Ventura	1	33%	2	67%	3
TOTAL	688	61%	436	39%	1124

Membership Stats

Category	Count	Percentage
Total Number of Members	573	
Total Acreage	205,992.08	
Sum of Acreage - North	139,673.85	68%
Sum of Acreage - South	64,572.22	32%

Exceedance Notification Letters Not Released

Staff requested letters to verify that members were contacting well users and providing replacement water.

- Activist groups also demanded they be made public (submitted to the Regional Board and available by request)
- In response, CCGC came up with an alternative approach

The Regional Water Board voted unanimously on November 13, 2014 to support CCGC's proposed compromise.

- This approach enables Staff to verify without the letters.

Regional Board staff has committed to only requesting copies of the letters in "extraordinary" situations.

CCGC Alternative Letters

The “Relational Key”

- Supplemental list submitted by CCGC relating the ranch-specific Global ID to the CCGC Field Point Name (well identifier)

Extended Exceedance Report

- Reporting exceedance follow up information by Field Point Name, such as:
  - Replacement water action
  - Date users notified of the exceedance
  - Manner in which users notified

CRLA Petition

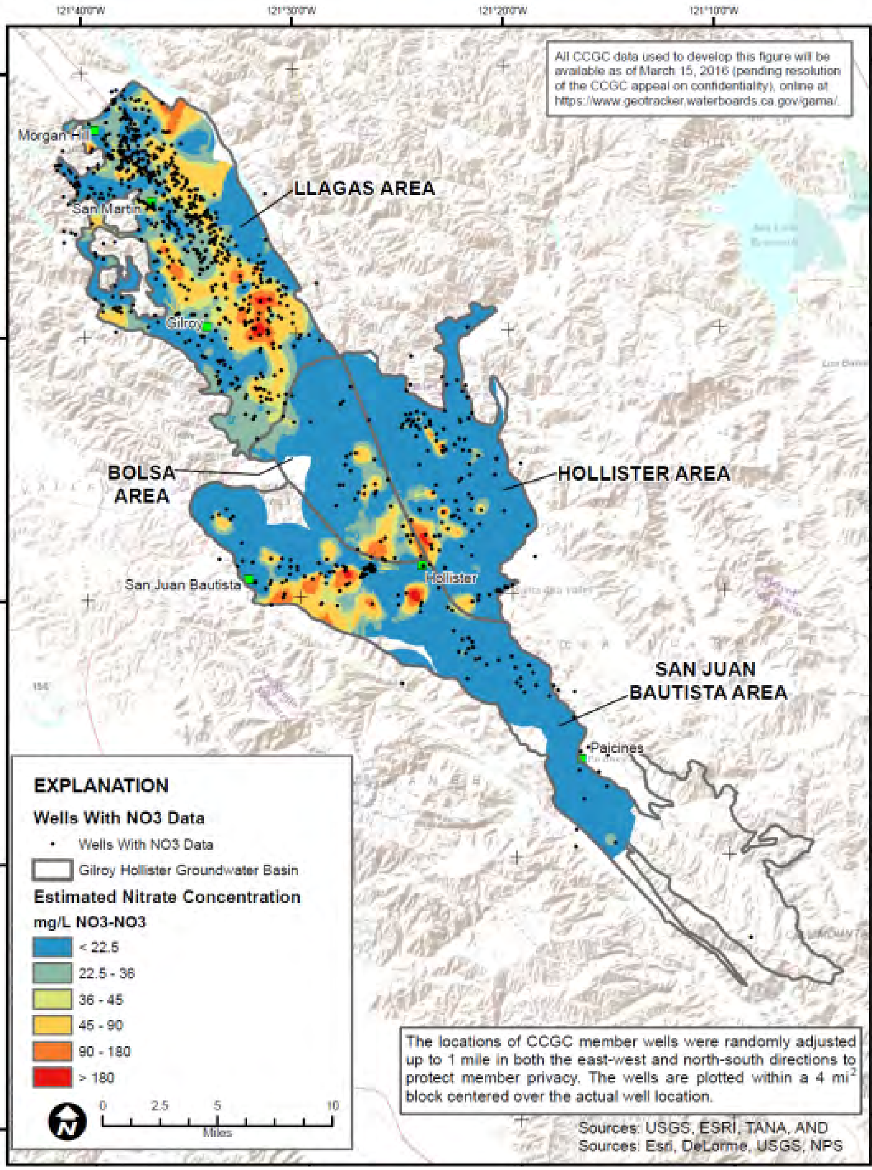
CRLA Files Petition to State Water Board Against CCGC Program

- Submitted January 7, 2015 by California Rural Legal Assistance and Environmental Law Foundation
- Main complaints:
  - Exceedance letters and their responses not submitted to the Regional Board/public
  - Keeping CCGC data off of public side of GeoTracker
  - The use of contour maps to display water quality data

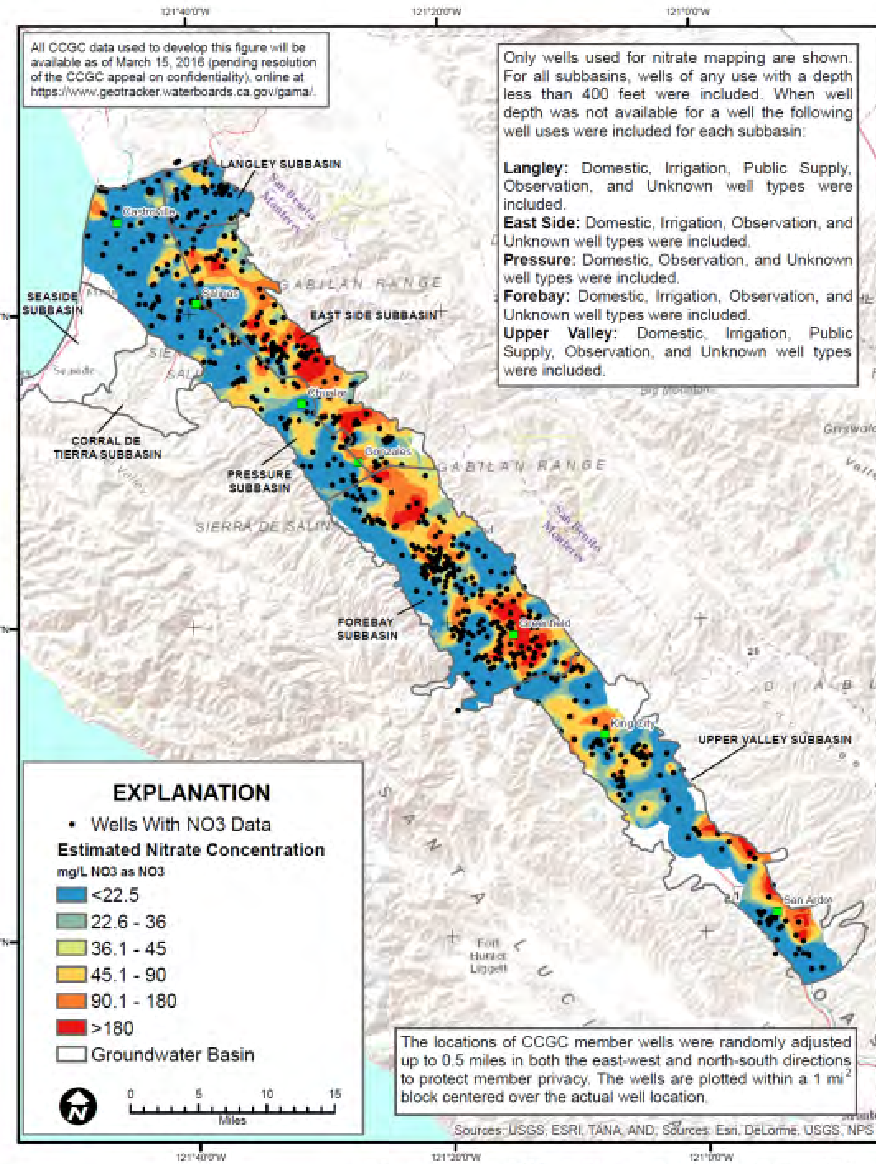
CCGC Petition

Contour Maps Rejected

- Regional Board claims contour levels inadequate to be sole method of aquifer characterization released to public
- Claim to need supporting data to be public for interested parties to perform own analyses
- CCGC Filed Petition to State Water Resources Control Board



121°40'0"W
121°30'0"W
121°20'0"W
121°10'0"W
37°10'0"N
37°0'0"N
36°50'0"N
36°40'0"N
36°30'0"N
All CCGC data used to develop this figure will be available as of March 15, 2016 (pending resolution of the CCGC appeal on confidentiality), online at https://www.geotracker.waterboards.ca.gov/gama/.
Morgan Hill
San Martin
Gilroy
LLAGAS AREA
BOLSA AREA
HOLLISTER AREA
San Juan Bautista
Hollister
SAN JUAN BAUTISTA AREA
Paicines
EXPLANATION
Wells With NO3 Data
Wells With NO3 Data
Gilroy Hollister Groundwater Basin
Estimated Nitrate Concentration
mg/L NO3-NO3
< 22.5
22.5 - 36
36 - 45
45 - 90
90 - 180
> 180
0
2.5
5
10
Miles
The locations of CCGC member wells were randomly adjusted up to 1 mile in both the east-west and north-south directions to protect member privacy. The wells are plotted within a 4 mi² block centered over the actual well location.
Sources: USGS, ESRI, TANA, AND
Sources: Esri, DeLorme, USGS, NPS



121°40'0"W
121°20'0"W
121°0'0"W
36°40'0"N
36°20'0"N
36°0'0"N
All CCGC data used to develop this figure will be available as of March 15, 2016 (pending resolution of the CCGC appeal on confidentiality), online at https://www.geotracker.waterboards.ca.gov/gama/.
Only wells used for nitrate mapping are shown. For all subbasins, wells of any use with a depth less than 400 feet were included. When well depth was not available for a well the following well uses were included for each subbasin:
Langley: Domestic, Irrigation, Public Supply, Observation, and Unknown well types were included.
East Side: Domestic, Irrigation, Observation, and Unknown well types were included.
Pressure: Domestic, Observation, and Unknown well types were included.
Forebay: Domestic, Irrigation, Observation, and Unknown well types were included.
Upper Valley: Domestic, Irrigation, Public Supply, Observation, and Unknown well types were included.
LANGLEY SUBBASIN
Castroville
SEASIDE SUBBASIN
Salinas
GABILAN RANGE
EAST SIDE SUBBASIN
Chualar
CORRAL DE TIERRA SUBBASIN
PRESSURE SUBBASIN
Gonzales
GABILAN RANGE
SIERRA DE SALINAS
FOREBAY SUBBASIN
Soledad
King City
UPPER VALLEY SUBBASIN
San Ardo
EXPLANATION
Wells With NO3 Data
Estimated Nitrate Concentration
mg/L NO3 as NO3
<22.5
22.6 - 36
36.1 - 45
45.1 - 90
90.1 - 180
>180
Groundwater Basin
0
5
10
15
Miles
The locations of CCGC member wells were randomly adjusted up to 0.5 miles in both the east-west and north-south directions to protect member privacy. The wells are plotted within a 1 mi² block centered over the actual well location.
Sources: USGS, ESRI, TANA, AND, Sources: Esri, DeLorme, USGS, NPS

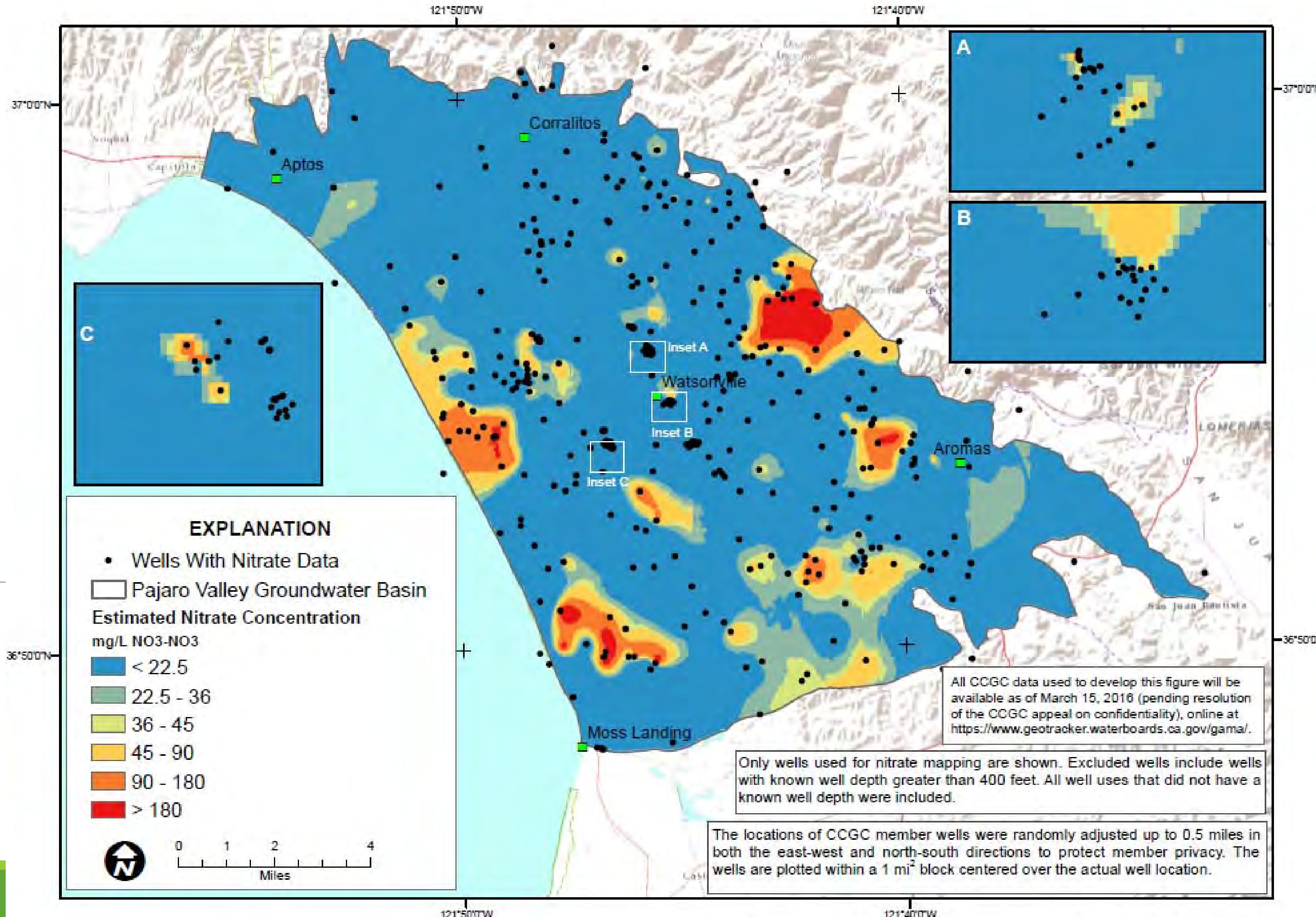


Figure 5. Kriged Nitrate Concentrations in Pajaro Valley

Table 1.

Set	Unique Genotypes Screened	Total Genotypes Screened	Total Plants Screened
1	9	9	149
2	11	12	107
3	42	48	602
4	58	76	939
5	19	35	400
Total	139	180	2197

Figure 1. OK ratings of clonal trees

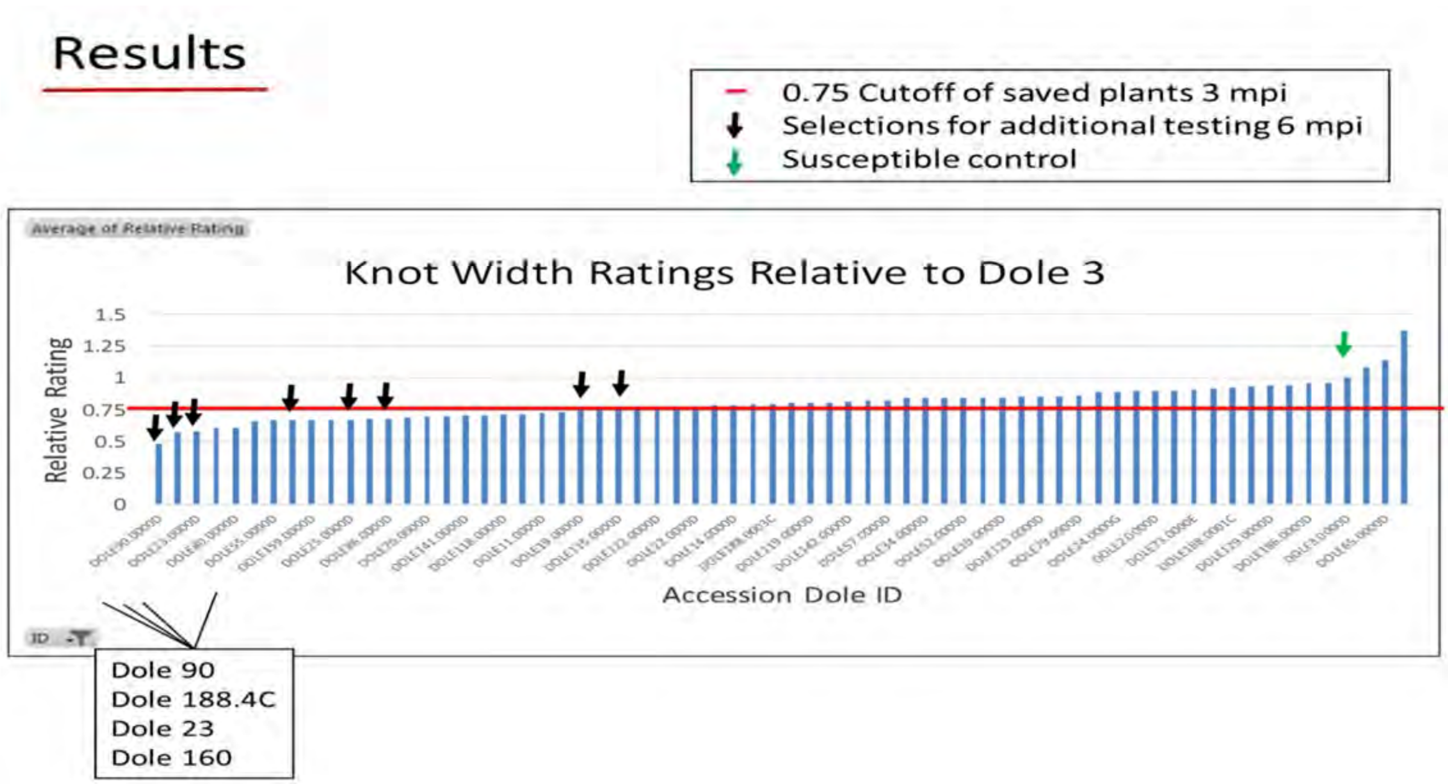


Figure 2. Secondary OK ratings of clonal trees.

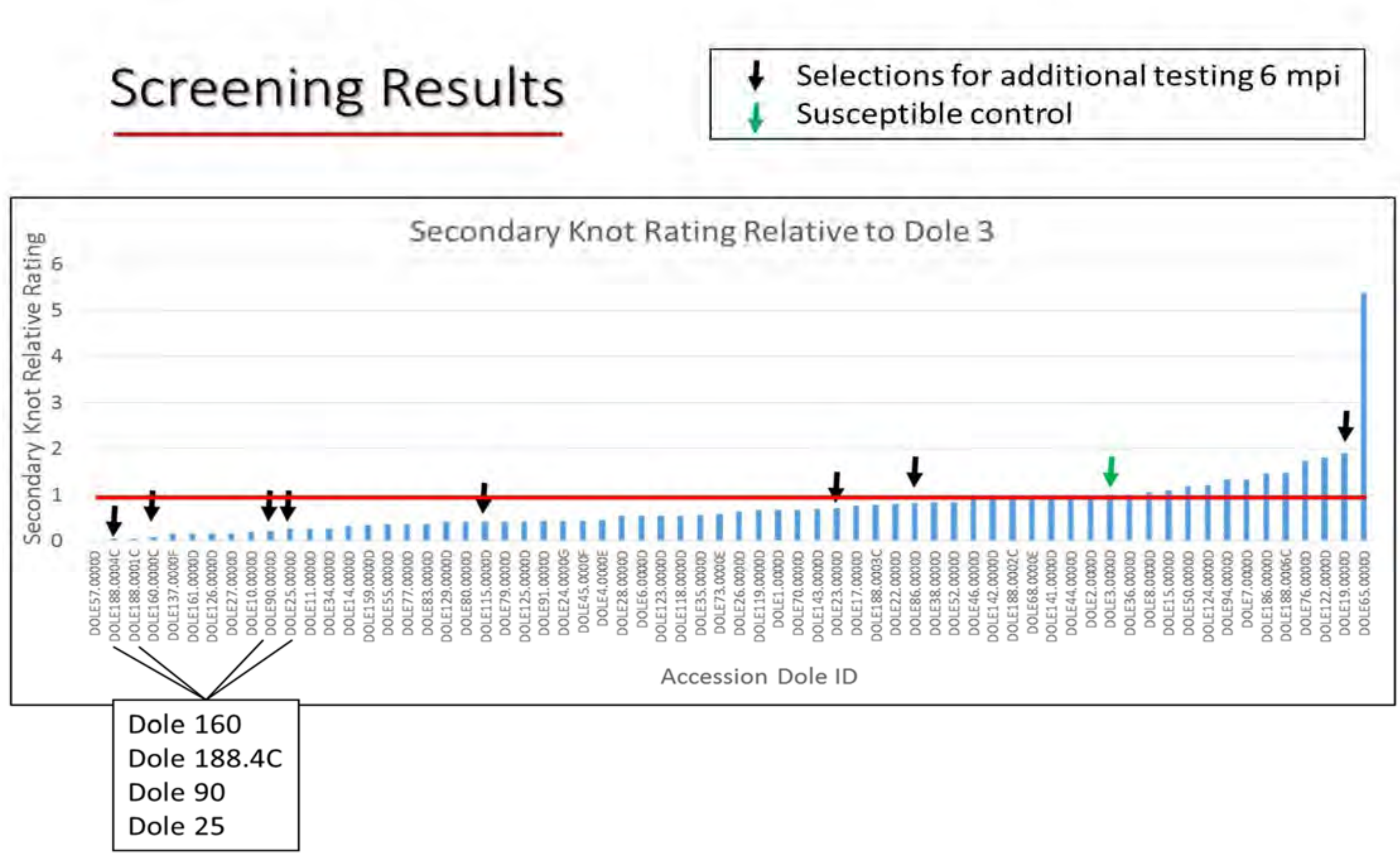


Figure 3. Composite OK ratings of clonal trees

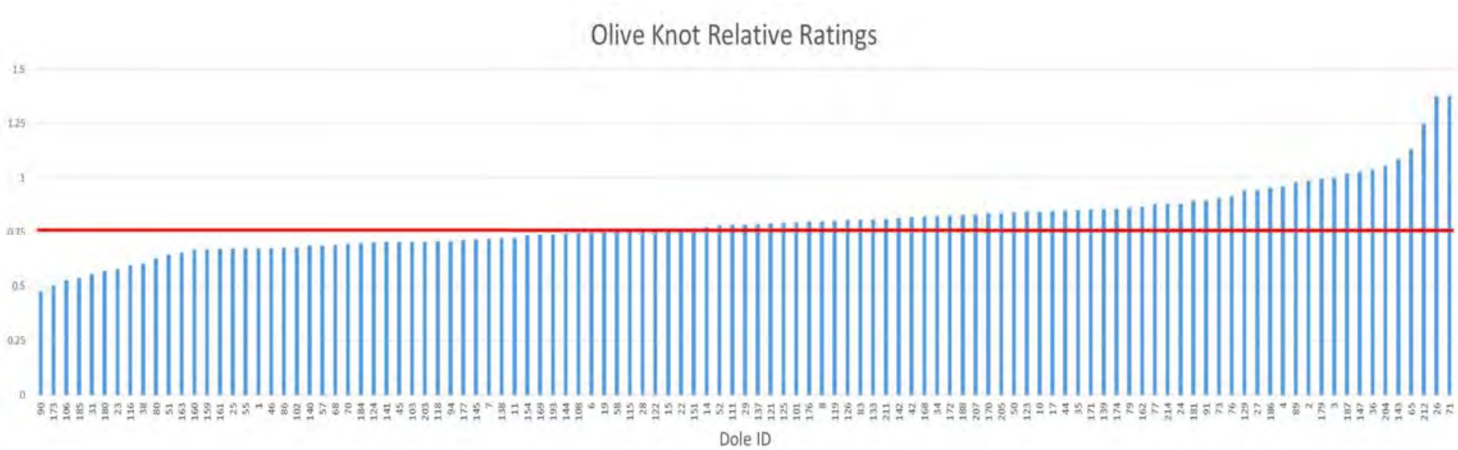
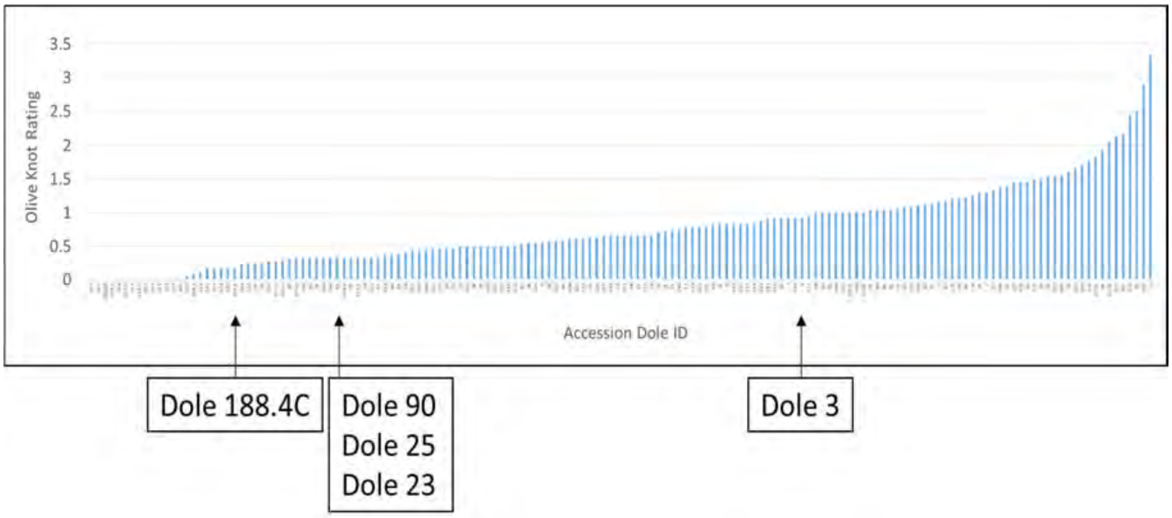


Figure 4.



3.5
3
2.5
2
1.5
1
0.5
0
Olive Knot Rating
Accession Dole ID
Dole 188.4C
Dole 90
Dole 25
Dole 23
Dole 3

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CTTGGGAACTGTGACATATGG	21	5.05776	AT1G80500.1	w7w28
CCCGAACCGAACCGAACCCGAAAT	24	4.98409	AT3G27750.1	w7
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TCTAGTCCGACTTTGTGAAAT	21	8.51322	AT1G67980.1	w28
ATTCTGGTAGATTGTGGGTGA	21	6.73881	AT1G16760.1	w28
ATATTTTCTGCAACATGATTGT	22	6.21688	AT1G77680.1	w28
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TCGGACCAGGCTTCATTTTTTT	22	5.65045	miR166	w28
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ATTCCTTAACTAACAATTTATAG	23	5.59582	AT4G36070.1	w28
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TCCAAAGGGATCGCATTGATTT	22	3.54926	miR393	w28
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CCGTTTCATCTTGTCCTCCAG	21	4.76418	w7
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TTGGACCAGGCTTCATTCCCC	21	4.67305	w7
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TCGGACCAGGCTTCATTCCAC	21	3.29908	w28
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TTTCGGACCAGGCTTCATTCC	21	3.17482	w28
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GCTGCCTGCGACGTCGCGAGA	21	3.04319	w28
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TGAGACTGCGTATTGTTGACCT	22	3.68899	w7
CTGAGACTGCGTATTGTTGACC	22	3.66774	w7
TACCGAACATCAACGCTGTAGA	22	3.6119	w7
TCGAGGACTGAACGTAAGTGTA	22	3.61078	w7
TTCTGTGAACCTTTCTGACGAA	22	3.53056	w7
TTACGGCTTTGATTTCAGTACT	22	3.48149	w7
CATCGAGGACTGAACGTAAGT	21	3.40352	w7
CGAAACTGGTGTGACTAGAACT	22	3.40228	w7
GTACACTCTATGAAGTCGGACA	22	3.40125	w7
GATAAGGCATCGAGGACTGAACGT	24	3.39955	w7
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CGCTAGTATCGTTCATCGTAAC	22	3.31539	w7
ACCGAACATCAACGCTGTAGACGT	24	3.31164	w7
CGAACATCAACGCTGTAGACGT	22	3.30961	w7
AGACAATAACCGGATGGGTAAA	22	3.30871	w7
CGCGAGAATAATAGGAGTGTG	21	3.28864	w7
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CCGTTGTAACAATCTCGTCGCT	22	3.23284	w7
TATCCTCTCGTTGGTCTAAGCT	22	3.21714	w7
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CAGCGCAACAGATGTCATGGGC	22	3.18727	w7
TTACCGAACATCAACGCTGTAGA	23	3.18548	w7
AACGAAGACACCTCGTCGGAGT	22	3.17958	w7
TAAGGCATCGAGGACTGAACG	21	3.16619	w7
TACGGAAAAACAGTTATCAAGG	22	3.14353	w7
CGATGAACGATACTAGCGGACA	22	3.1341	w7
TAAGGCATCGAGGACTGAACGT	22	3.1212	w7
GTGTGACTAGAACTCATGTACC	22	3.12088	w7
GTTACCGAACATCAACGCTGTAGACGT	27	2.96085	w14
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GATAAGGCATCGAGGACTGAACGT	24	2.69934	w14
CACAGGGCTCTGCTAAGTCGGCTT	24	2.68911	w14
ACATCAGGACTCGAGTAGGGCGGA	24	2.6379	w14

AGGGACTATGGCCGCTTAGGCCAAGG	26	2.6117	w14
CGGATCATGTGTGTTGTCATCCCT	24	2.52338	w14
AGTAATGATTAACAGGGACAGTCG	24	2.47872	w14
GTAGGTGAACCTGCGGAAGGATCATTG	27	2.45318	w14
TGGAGAAGCGTCCTCAGCGGCGGACC	26	2.43873	w14
ATAAGCCCGCCTGACTGCGAGACT	24	2.43115	w14
CGGGCGTCGAACAGTCGACTCAGAA	25	2.30429	w14
CGAACGCGGACCAGGCCAGTGCCT	24	2.26903	w14
GGCTAAGGTCGGCGCAGTTGTGGAACC	27	2.24058	w14
ACGCGTGGGAATCTGCCCCTTGGTT	25	2.23534	w14
AACATCAGGACTCGAGTAGGGCGG	24	2.18258	w14
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GATAAGGCATCGAGGACTGAACGT	24	1.82981	w28
ACACAGGGCTCTGCTAAGTCGGCT	24	1.82239	w14
GTTACCGAACATCAACGCTGTAGACC	26	1.82113	w14
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GATAAGGCATCGAGGACTGAACGTA	25	1.79038	w14
CTATGCGGAGGTATCCCTCCGTGGCCA	27	1.78884	w14
AATGATTAACAGGGACAGTCGGGG	24	1.77552	w14
TGGGTCGTGGAGGTATCGGAAGTG	24	1.76296	w14
GTTACCGAACATCAACGCTGTAGACT	26	1.74299	w14
ATGGGTCGTGGAGGTATCGGAAGTG	25	1.7219	w14
TGAGGTTCTTGGGGAGAGTAG	21	1.70634	w28
AACATCAGGACTCGAGTAGGGCGGA	25	1.70509	w14
GAGGGGCTGATGAAGTTGTAGTTACCT	27	1.66038	w14
TCTTTAAAATGATCGAGGGGCC	22	1.64727	w28
ATCTCTACGGAGCTGATACCTACT	24	1.64545	w28
GTAAGTTCGGAAGCGGATCGCTTGGC	26	1.64327	w14
GCGAACGCGGACCAGGCCAGTGCCT	25	1.63567	w14
ACGGGTATGGAAAAGGGGCGCC	22	1.61857	w28
TGCGGGTTCAAGTCCCGTCGGTCGCCC	27	1.60917	w14
GTTACCGAACATCAACGCTGTAGA	24	1.60704	w28
GACCATCCTGATGATCGCCGTTCATGT	27	1.57831	w14
TCCCGAACCCGTCGGCTGTCGGCGGAC	27	1.57446	w14
GCTCTAAAGTGTTTGGTAAACACT	24	1.56364	w28

Attachment 1

Table 4. List of bacteria associated with gastropod nematodes in culture[1].

Item	Bacterial taxa	Frequency of isolates
1	Achromobacter sp.	2
2	Alcaligenes faecalis	28
3	Alcaliegenes sp.	7
4	Bacillus cereus	1
5	Bacillus licheniformis	8
6	Bacillus niacini	1
7	Bacillus pumilus	5
8	Bacillus safensis	4
9	Bacillus subtilis	1
10	Bacillus sp.	3
11	Brevibacterium sp.	1
12	Brevundimonas diminuta	6
13	Brevundimonas naejangsanensis	1
14	Citrobacter freundii	1
15	Enterobacter sp.	1
16	Flavobacterium sp.	4
17	Herbaspirillum frisingense	1
18	Klebsiella oxytoca	1
19	Leucobacter chromiireducens	1
20	Microbacterium keratanolyticum	1
21	Microbacterium oxydans	3
22	Microbacterium resistens	3
23	Microbacterium sp.	1
24	Myroides odoratus	2
25	Ochrobactrum sp.	6
26	Paenibacillus sp.	3
27	Pseudochrobactrum lubricantis	1
28	Pseudochrobactrum saccharolyticum	5
29	Pseudomonas composti	2
30	Pseudomonas protegens and Pseudomonas fluorescens	1
31	Pseudomonas putida	2
32	Pseudomonas sp.	3
33	Pusillimonas sp.	1
34	Rheinheimera tangshanensis	1
35	Rhodococcus erythropolis	1
36	Sphingobacterium mizutaii	1
37	Sphingobacterium sp., Sphingobacterium composti	1
38	Stenotrophomonas and Xanthomonas	1
39	Stenotrophomonas maltophilia	1
40	Stenotrophomonas sp.	1

[1]Jackson *et al.*, 2015. Ms in prep. Identity based on 16S rDNA sequences

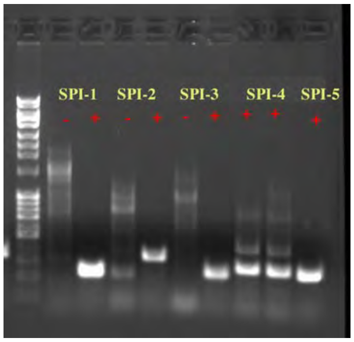


Fig. 1. PCR confirmation of *Salmonella* Pathogenicity Island (SPI) deletions in the surrogate strain. Primers flanking deleted regions were used to confirm deletions of each of the SPI's. "+" denote *Salmonella* wild type template, and "-" is surrogate. Note that SPI1, SPI-2 and SPI3 are over 10Kb, and the observed smearing in the wild type lanes is a result of non-specific binding.

Table 1. Recovery of the wild type *Salmonella* and surrogate from BALB/c mouse organs

Infectious dose	**1.20E+07**			**1.20E+05**		**1.20E+03**	
	Wild type		***Surrogate***	***Wild type***	***Surrogate***	***Wild type***	***Surrogate***
	Mean	St. deviation	Mean	Mean	Mean	Mean	Mean
Spleen	2.00E+05	8.42E+04	0.00E+00	1071.43	0.00E+00	1.50E+01	0.00E+00
Liver	5.91E+04	2.42E+04	0.00E+00	1.02E+02	0.00E+00	7.50E-01	0.00E+00
Large Intestine	1.58E+05	7.67E+04	0.00E+00	7.50E-01	0.00E+00	0.00E+00	0.00E+00
Peyer's Patches	3.18E+06	3.89E+06	0.00E+00	20.00	0.00E+00	0.00E+00	0.00E+00

Table 2. 7-day Survival of mice infected with the wild type and surrogate strains of *Salmonella*

Strain	**Dose**	**Survival**
wild type	1.20E+07	0
wild type	1.20E+05	3
wild type	1.20E+03	3
surrogate	1.00E+08	3
surrogate	1.00E+06	3
surrogate	1.00E+04	3

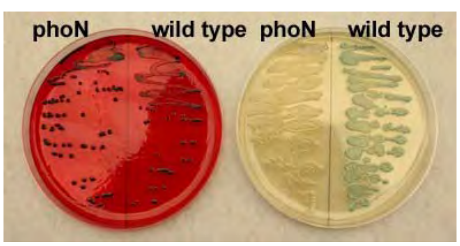


Fig. 2. Culture-based detection and identification of the *Salmonella* surrogate. Surrogate and wild type strains on the XLD medium (indistinguishable). Surrogate and the wild type strain on LB medium with 5-bromo-4-chloro-3-indolylphosphate

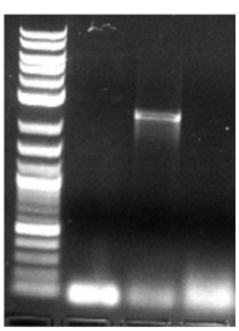


Fig. 3. PCR with *hilA*-specific primers. Lane 1: ladder, Lane 2: negative controls (no template), Lane 3: wild type. The band corresponding to *hilA* is clearly visible, lane 4: avirulent mutant

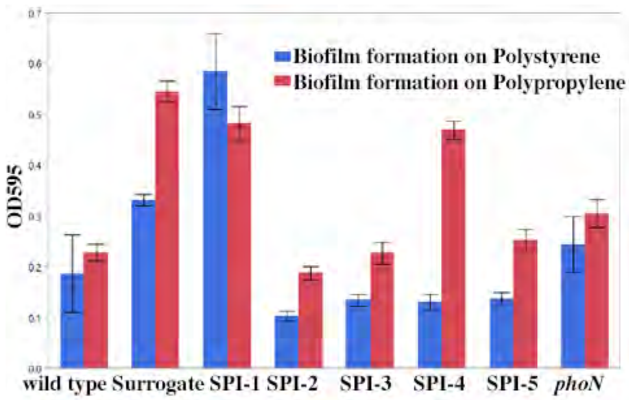


Fig. 4. Biofilm formation by the wild type and avirulent strains on abiotic surfaces.

Table 3. Inoculated *Salmonella* SPI mutant populations on cut romaine leaves at 4°C.

	Time (d)												
Strain	0	1		2		5		7		14		21	
WT	6.1 ± 0.0	6.1 ± 0.0	BC[1,2]b[3]	5.8 ± 0.1	Ba	5.7 ± 0.1	Ba	5.6 ± 0.2	Ba	5.7 ± 0.2	Ba	5.5 ± 0.2	Ba
SPI 1	6.0 ± 0.1	6.1 ± 0.1	Cd	5.5 ± 0.0	Ba	5.9 ± 0.1	Bcd	5.6 ± 0.2	Bab	5.8 ± 0.1	Bbc	5.8 ± 0.1	Bbc
SPI 2	6.1 ± 0.1	5.2 ± 0.4	Ab	4.8 ± 0.4	Ab	3.0 ± 0.8	Aa	3.1 ± 0.4	Aa	2.8 ± 0.3	Aa	3.0 ± 0.2	Aa
SPI 3	6.1 ± 0.2	5.8 ± 0.1	BCb	5.9 ± 0.1	Bb	5.9 ± 0.1	Bb	5.7 ± 0.2	Bab	5.9 ± 0.1	Bb	5.3 ± 0.4	Ba
SPI 5	6.2 ± 0.1	6.1 ± 0.1	BCc	6.0 ± 0.1	Bbc	6.0 ± 0.1	Bbc	5.8 ± 0.1	Bbc	5.9 ± 0.3	Bbc	5.3 ± 0.2	Ba
phoN	5.9 ± 0.2	5.8 ± 0.1	BCa	5.8 ± 0.2	Ba	5.7 ± 0.1	Ba	5.4 ± 0.1	Ba	5.4 ± 0.3	Ba	5.6 ± 0.2	Ba
SPI 4	6.2 ± 0.1	5.9 ± 0.1	BCb	5.9 ± 0.2	Bb	5.8 ± 0.2	Bb	5.8 ± 0.3	Bb	5.4 ± 0.3	Ba	5.2 ± 0.1	Ba
Surrogate	6.1 ± 0.0	6.0 ± 0.2	BCb	5.9 ± 0.2	Bab	5.8 ± 0.2	Bab	5.9 ± 0.1	Bab	5.7± 0.1	Bab	5.9 ± 0.1	Bab

Values are means (log CFU/leaf) ± standard deviations (n=6).
[1]Means calculated based on normalized data, accounting for differences in initial concentration at d0.
[2]Means with the same capital letter in each column are not significantly different (P > 0.05).
[3]Means with the same lowercase letter in each row (i.e., same strain) are not significantly different (P > 0.05).

Table 4. Inoculated *Salmonella* SPI mutant populations on cut romaine leaves at 10°C.

	Time (d)								
Strain	0	1		2		5		7	
WT	6.1 ± 0.1	5.9 ± 0.5	B[1,2]a[3]	5.8 ± 0.3	Ba	5.8 ± 0.3	Ba	5.8 ± 0.1	Da
SPI 1	6.2 ± 0.1	5.8 ± 0.1	Bc	5.5 ± 0.2	Bc	5.4 ± 0.1	Bb	5.0 ± 0.2	Ba
SPI 2	6.4 ± 0.1	5.5 ± 0.1	Ab	3.9 ± 0.4	Aa	3.9 ± 0.8	Aa	4.5 ± 0.3	Aa
SPI 3	6.3 ± 0.1	5.8 ± 0.2	ABa	5.8 ± 0.2	Ba	5.7 ± 0.2	Ba	5.7 ± 0.1	CDa
SPI 5	6.4 ± 0.1	6.0 ± 0.2	ABa	5.9 ± 0.1	Ba	6.0 ± 0.1	Ba	5.9 ± 0.1	CDa
phoN	6.2 ± 0.1	6.0 ± 0.3	Ba	5.9 ± 0.3	Ba	5.8 ± 0.2	Ba	5.6 ± 0.1	CDa
SPI 4	6.5 ± 0.0	6.1 ± 0.3	ABb	6.0 ± 0.1	Bab	5.8 ± 0.1	Bab	5.7 ± 0.3	Ca
Surrogate	6.5 ± 0.1	6.1 ± 0.1	ABa	6.1 ± 0.2	Ba	5.8 ± 0.3	Ba	6.0 ± 0.1	Da

Values are means (log CFU/leaf) ± standard deviations (n=6).
[1]Means calculated based on normalized data, accounting for differences in initial concentration at d0.
[2]Means with the same capital letter in each column are not significantly different (P > 0.05).
[3]Means with the same lowercase letter in each row (i.e., same strain) are not significantly different (P > 0.05).

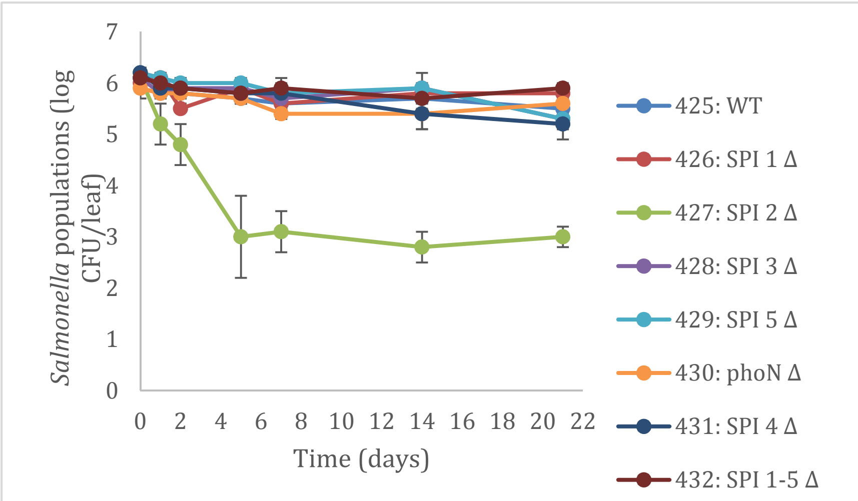


Figure 4. Fate of *Salmonella* SPI mutants on cut romaine leaves at 4°C.

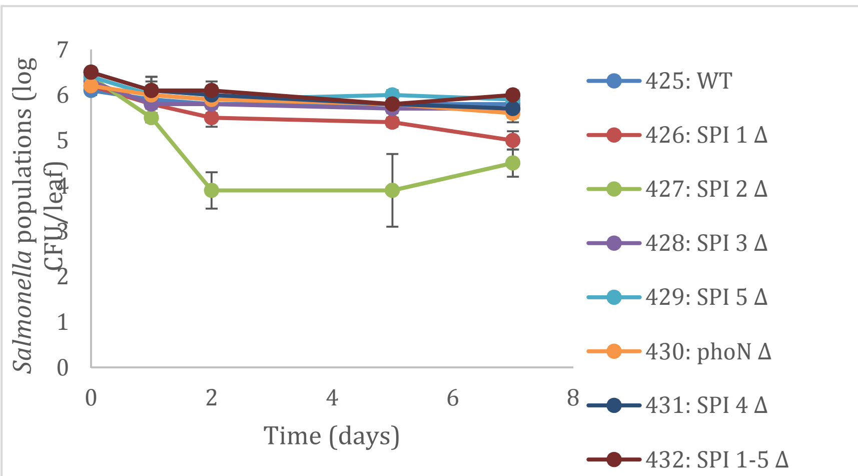


Figure 5. Fate of *Salmonella* SPI mutants on cut romaine leaves at 10°C.

Level			Mean
phoN	A		96517.5
-pLST	A	B	24681
SPI-2	A	B	17088
SPI-3	A	B	15788
14028		B	13729
SPI-1		B	9497
SPI-5		B	8933
SPI-4	A	B	5134

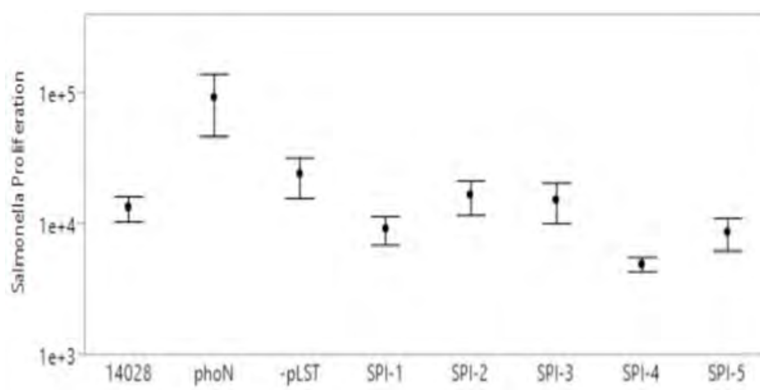


Fig. 6. Proliferation of the avirulent strains and the parental wild type inside red tomatoes.

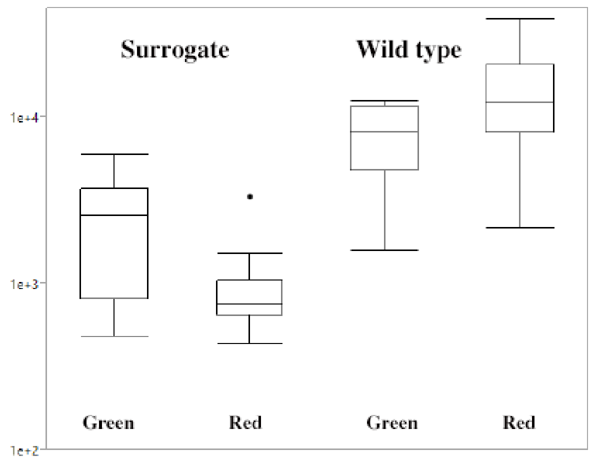


Fig. 7. Proliferation (measured as a ratio of recovered/inoculated CFU) of the surrogate strain and the parental wild type inside red and green tomatoes.

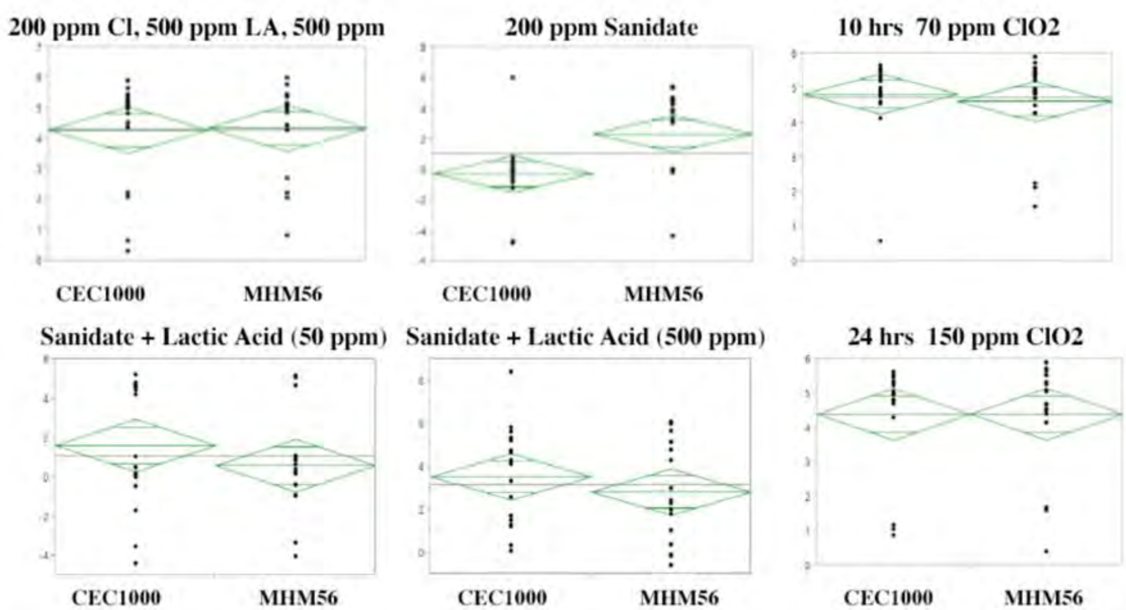


Fig. 8. Susceptibility of the avirulent (lacking SPIs) strain MHM56 and a wild type strain CEC1000 to common disinfectants.

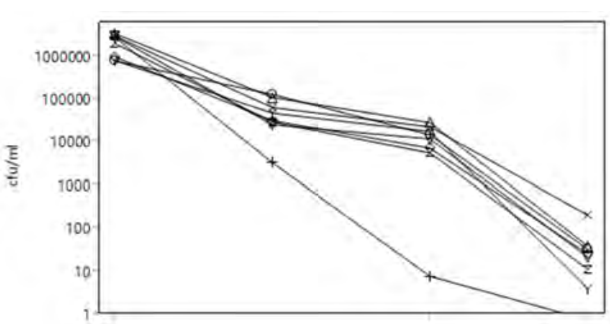


Fig. 9. Survival of the avirulent strains in well water at 22C. Empty circle is *Salmonella* Typhimurium 14028 (wild type), plus sign is *Salmonella phoN* mutant, diamond depicts a strain lacking the virulence plasmid pSLT, an "x" depicts a SPI-1 mutant, upward triangle is a SPI-2 mutant, a "y" is a SPI-3 mutants, a downward triangle is SPI-4, while a "z" is a SPI-5 mutant

Table 5. Inoculated *Salmonella* SPI mutant populations in EPA worst-case water at 25°C.

	Time (d)												
Strain	0	1		2		5		7		14		21	
WT	5.9 ± 0.1	6.1 ± 0.1	A[1,2]a[3]	6.1 ± 0.0	BCa	6.0 ± 0.0	Ba	6.1 ± 0.1	Ca	6.2 ± 0.2	Ba	6.1 ± 0.5	BCa
SPI 1	4.9 ±0.1	4.8 ± 0.2	Ab	4.9 ± 0.1	ABCb	4.8 ± 0.2	ABb	4.6 ± 0.2	ABb	4.0 ± 0.3	ABa	3.9 ± 0.1	Aa
SPI 2	5.2 ± 0.1	5.3 ± 0.2	Ad	5.0 ± 0.2	Acd	4.7 ± 0.2	Abc	4.5 ± 0.3	Ab	3.9 ± 0.5	ABa	3.8 ± 0.4	Aa
SPI 3	5.4 ± 0.4	5.4 ± 0.6	Aab	5.6 ± 0.4	BCab	5.4 ± 0.6	Bab	5.3 ± 0.8	BCab	5.7 ± 0.2	Aa	6.1 ± 0.4	Cb
SPI 5	6.0 ± 0.1	5.9 ± 0.1	Ab	6.0 ± 0.1	ABCb	5.9 ± 0.1	Bb	5.9 ± 0.1	BCb	5.5 ± 0.2	ABa	5.8 ± 0.2	Bb
phoN	5.9 ± 0.1	6.0 ± 0.0	Aa	6.0 ± 0.2	ABa	6.1 ± 0.0	Ba	6.1 ± 0.0	Ca	5.9 ± 0.1	ABa	6.0 ± 0.1	BCa
SPI 4	5.6 ± 0.2	5.8 ± 0.3	Ab	5.7 ± 0.1	ABCab	5.5 ± 0.4	ABab	5.6 ± 0.2	BCab	5.1 ± 0.5	ABa	5.7 ± 0.1	BCab
surrogate	5.4 ± 0.1	5.6 ± 0.1	Ab	5.7 ± 0.1	Cb	5.6 ± 0.1	Bb	5.4 ± 0.2	Cab	5.2 ± 0.3	ABa	5.6 ± 0.1	BCb

Values are means (log CFU/g) ± standard deviations (n=6).
[1]Means calculated based on normalized data, accounting for differences in initial concentration at d0.
[2]Means with the same capital letter in each column are not significantly different (P > 0.05).
[3]Means with the same lowercase letter in each row (i.e., same strain) are not significantly different (P > 0.05).

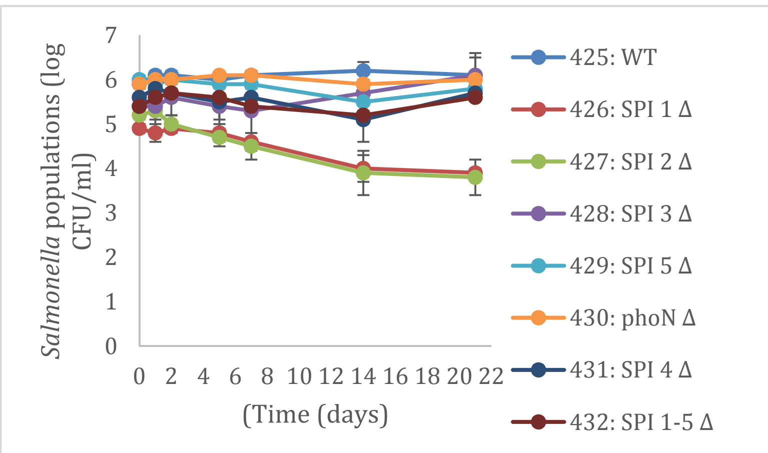


Fig.10. Survival of individual *Salmonella* mutants and avirulent surrogate in EPA worst-case water at 25C.

Table 6. Survival of *Salmonella* SPI mutant populations in soil at 25°C.

	Time (d)												
Strain	0	1		2		5		7		14		21	
Wild type	5.7 ± 0.1	5.8 ± 0.1	AB[1,2]d[3]	6.0 ± 0.1	Dd	5.7 ± 0.1	Ed	5.1 ± 0.1	BCc	4.6 ± 0.2	Cb	3.8 ± 0.2	DEa
SPI 1	4.8 ± 0.2	4.1 ± 0.4	Ad	3.6 ± 0.4	ABcd	3.0 ± 0.3	BCDEbc	2.2 ± 0.2	Aa	2.1 ± 0.3	ABab	1.2 ± 0.7	ABCa
SPI 2	5.1 ± 0.2	4.6 ± 0.1	ABe	3.5 ± 0.4	Ad	2.9 ± 0.2	ABCcd	2.4 ± 0.5	Abc	2.0 ± 0.7	Aab	0.7 ± 0.7	Aa
SPI 3	5.4 ± 0.2	5.1 ± 0.9	ABb	5.0 ± 0.1	BCDb	4.4 ± 0.9	CDEab	4.4 ± 1.0	Bab	4.0 ± 1.1	BCab	3.3 ± 1.0	CDEa
SPI 5	5.5 ± 0.1	5.3 ± 0.3	ABb	5.3 ± 0.2	BCDb	3.6 ± 0.4	ABCDa	4.0 ± 0.3	Ba	3.8 ± 0.6	BCa	3.5 ± 0.3	CDEa
phoN	5.6 ± 0.0	5.9 ± 0.1	Be	6.1 ± 0.0	Df	5.4 ± 0.1	DEc	5.7 ± 0.1	Cd	4.8 ± 0.1	Cb	4.3 ± 0.1	Ea
SPI 4	5.4 ± 0.2	5.0 ± 0.7	ABc	4.7 ± 0.9	ABCbc	3.4 ± 0.5	Aa	4.1 ± 0.6	Babc	3.4 ± 1.1	BCabc	2.5 ± 1.5	BCDab
surrogate	5.0 ± 0.2	4.6 ± 0.7	ABcd	5.3 ± 0.2	CDd	3.0 ± 0.0	ABab	4.0 ± 0.3	Bcd	3.4 ± 0.6	BCbc	0.9 ± 1.0	ABa

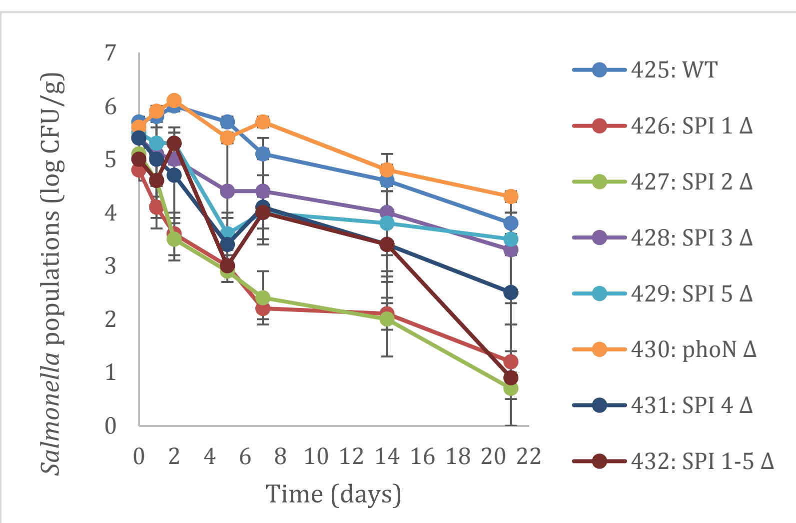
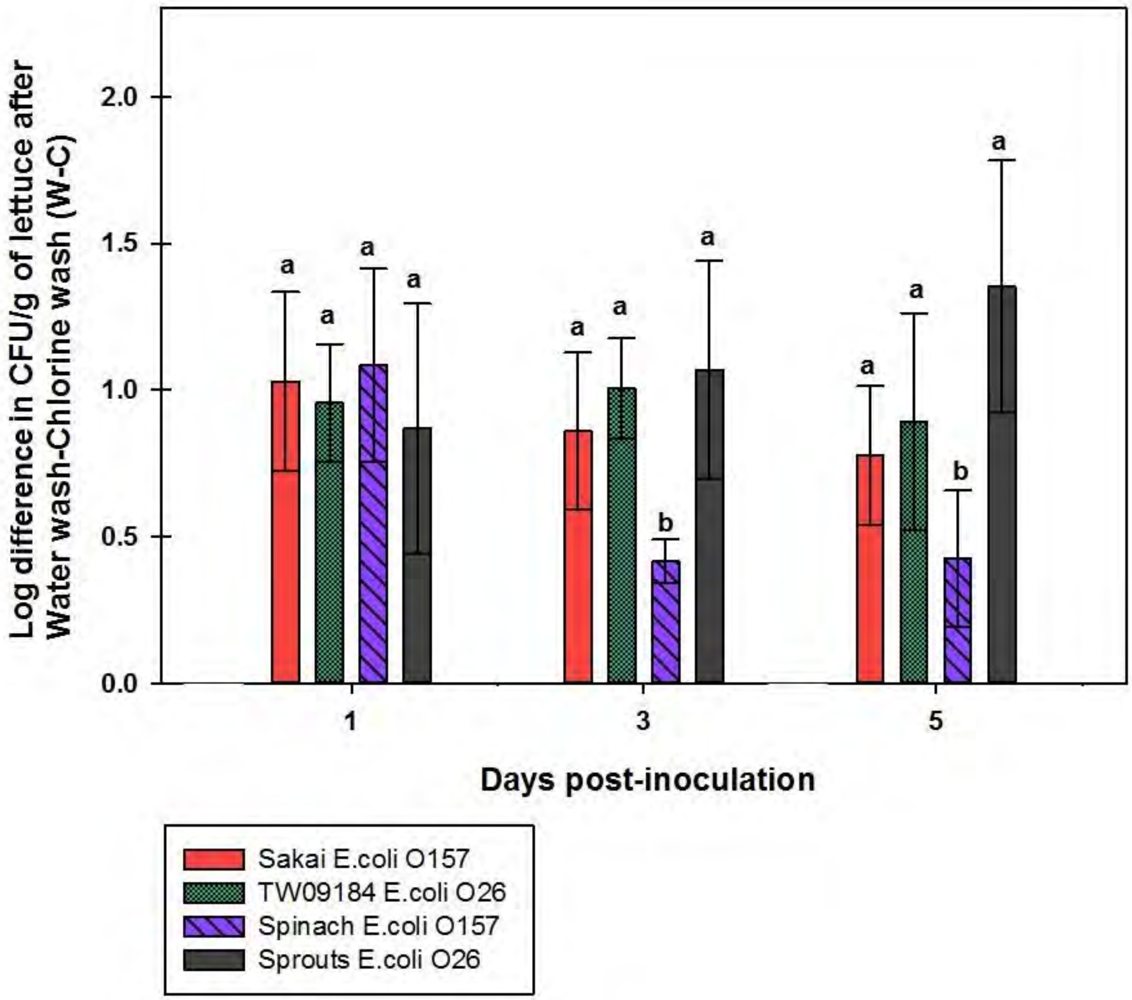


Fig. 11. Survival of individual *Salmonella* mutants and avirulent surrogate in non-sterile soil at 25C.

Attachment for SCB12065

A figure showing chlorine survival for different EHEC strains after 1, 3, and 5 days of inoculation is provided. Bars with different letters are significantly different. The EHEC O157 strain from the 2006 spinach outbreak had improved chlorine survival after 3 and 5 days on lettuce.



Food Control 50 (2015) 560–567

Contents lists available at ScienceDirect

Food Control

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A novel approach for measuring resistance of *Escherichia coli* and *Listeria monocytogenes* to hydrogen peroxide using label-free magnetic resonance imaging and relaxometry

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ARTICLE INFO

Article history:
Received 23 July 2014
Received in revised form
21 September 2014
Accepted 25 September 2014
Available online 7 October 2014

Keywords:
Magnetic resonance
Imaging
Sanitation
Bacteria
Hydrogen peroxide
Oxidative stress

ABSTRACT

Sanitation is a critical step to reduce microbial load in many process industries. To assess and monitor the efficacy of sanitation processes, there is a need to rapidly measure microbial resistance to sanitizers and determine the critical concentration of sanitizers above which significant reduction in microbial load can be achieved in a complex environment. In this study, a rapid and label-free magnetic resonance (MR) imaging and relaxometry method was developed to measure resistance of *Escherichia coli* and *Listeria monocytogenes* to hydrogen peroxide based on the activity of intracellular catalase enzymes. Intracellular catalase activity is a measure of resistance of bacteria to hydrogen peroxide as these enzymes can degrade hydrogen peroxide to oxygen and water. Using sub-lethal and lethal concentration of hydrogen peroxide, the resistance of both the exponential and stationary growth phase *E. coli* suspended in PBS and in high organic content solution was characterized. The results show that in stationary growth phase *E. coli*, molecular oxygen, generated by the interaction of endogenous catalases with 1% H_2O_2, results in an 8 fold increase in MR imaging signal intensity and a 22 fold decrease in spin-lattice relaxation time (T_1) compared to the controls. Furthermore, the resistance of *E. coli* and *L. monocytogenes* to H_2O_2, measured using the MR method, was correlated with the bacterial reduction, quantified with traditional plate counting method. The comparison between the two methods shows the MR method developed in this study can determine the critical concentration of H_2O_2 above which a significant reduction in bacterial culturability (at least 4 logs) was achieved. Overall, this study demonstrates the potential of MR imaging and relaxometry method to predict the efficacy of H_2O_2 in high organic load environment.

1. Introduction

The primary goal of sanitation is to reduce microbial load in diverse products and process operations (Beck-Sague et al., 1990; Chu, McAlister, & Antonoplos, 1998; Doan et al., 2012; Nakazato et al., 2007; Sapers & Sites, 2003). For sanitation in food, environmental, and medical industry, various oxidizing agents such as hydrogen peroxide (H_2O_2), ozone, and chlorine are used. Among these diverse oxidizers, H_2O_2 is one of the most widely used sanitizers due to its broad-spectrum microbiocidal activity and ability to completely degrade without forming any residue (Linley, Denyer, McDonnell, Simons, & Maillard, 2012; Swartling & Lindgren, 1968).

To assess efficacy of sanitizers in diverse applications, a range of measurement approaches have been developed. In many process industries, such as water treatment and fresh produce washing, efficacy of sanitizers is assessed based on chemical methods to measure sanitizer concentration, total carbon content, oxidation reduction potential (ORP), turbidity, and/or pH of the aqueous phase (Newman, 2004; Suslow, 2000, 2004). Although chemical measurements such as ORP can assess the oxidation potential of water, these measurements are not effective in measuring reduction in bacterial count induced by sanitizers in complex environments with organic load. Furthermore, the ORP method is not a sensitive approach to measure the antimicrobial potential of H_2O_2 (Newman, 2004; Suslow, 2004).

In addition to chemical measurements, prior studies have investigated bacterial damages due to sanitizers based on changes in membrane potential, membrane permeability, DNA double strand breaks, and lipid peroxidation (Baatout, Boever, & Mergeay,

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http://dx.doi.org/10.1016/j.foodcont.2014.09.038

2006; Farr & Kogoma, 1991; Imlay & Linn, 1986; Linley et al., 2012). The key advantage of these approaches is to directly assess the damage induced by sanitizers to various functional elements such as membrane and DNA of the bacteria. These measurements can aid in developing mechanistic understanding of the action of sanitizers. The major limitations of this approach are: (a) multiple steps for preparing microbial samples including labeling of microbes with specific fluorophores and isolation of DNA; (b) limited sensitivity of fluorescence measurements in turbid environments; and (c) lack of correlation between the optical signal and the reduction in microbial count (Baatout et al., 2006; Kramer & Muranyi, 2014; Wang, Claeys, van der Ha, Verstraete, & Boon, 2010).

Complementary to these approaches, prior studies have also used gene expression analysis to assess response of bacteria to sanitizers (Farr & Kogoma, 1991; Ming Zheng, 1999). Most of the gene expression studies are conducted using a sub-lethal level of sanitizer concentration, thus enabling bacteria to adjust their gene expression in response to the oxidative stress induced by sanitizers. However, process industry uses lethal concentration levels of sanitizers and short period of time, which may not provide sufficient time (less than 5–15 min) for microbes to adjust their gene expression. Thus, these studies have limited application in assessing efficacy of sanitation operations.

Traditional plate counting has also been used in laboratory settings to study efficacy of sanitizers (Asaumi, Watanabe, Taguchi, Tashiro, & Otsuki, 2007). Traditional plate counting is an effective approach for measuring biocidal activity of various sanitizers; however, plate counting methods require at least 12–24 h to assess the reduction in microbial count.

The aim of this study was to develop a novel label free MR imaging and relaxometry method to measure bacterial resistance to H_2O_2 based on the activity of endogenous catalases, and correlate MR measurements with reduction in bacterial culturability. In MR imaging and relaxometry, signal intensity is based on the magnetic properties of the nuclei (protons) through their interaction with an applied radio frequency and a constant magnetic field (Zhang & McCarthy, 2012). The unique advantage of MR is its ability to measure reactions and interactions in turbid and opaque environments, where sensitivity of optical detection systems is limited. In environments with high solid content, chemical measurements are also challenging as the electrodes for the oxidation-reduction potential measurements can be easily fouled. MR imaging and relaxometry are non-destructive methods that have been used in the food, chemical, oil and pharmaceutical industry as quality assessment tools for many years (Metz & Mäder, 2008). Therefore, the method developed in this study can be easily integrated with the current MR systems used in industry. The experimental setup is illustrated in Fig. 1. Fig. 1(e) illustrates an example of a portable MR relaxometry device that could be used in industrial settings.

Escherichia coli (*E. coli*) BL21 was chosen as model bacteria to characterize and determine the mechanism of MR contrast generated upon interactions of bacteria with H_2O_2 with and without organic load. Both stationary and exponential phase bacteria (*E. coli* BL21) were examined as physiological state of bacteria can affect the resistance of bacteria to sanitizers. The results of MR based methodology were also validated using *E. coli* O157:H7 and *Listeria monocytogenes* (*L. monocytogenes*), and compared with the standard plate counting methods. *E. coli* O157:H7 and *L. monocytogenes* were selected as these microbial strains are the leading cause of food borne illness, and sanitation processes are often used to reduce the contamination of food with these pathogens. Furthermore, the selected bacteria represent both the gram-positive (*L. monocytogenes*) and the gram-negative strains (*E. coli* O157:H7).

2. Materials and methods

2.1. Materials

H_2O_2 (30% v/v), phosphate buffered saline (PBS 10× solution), and microbial culture media (LB –Lysogeny broth Miller) were obtained from Fisher Scientific (Pittsburgh, PA). Catalase enzyme isolated from bovine liver and Tris (2,2′-bipyridyl)dichlororuthenium (II) hexahydrate (Ru(BPY)$_3$) were purchased from Sigma Aldrich (St. Louis, MO).

2.2. Bacterial strains and culture condition

E. coli BL21 #BAA-1025 was purchased from ATCC (Manassas, VA). A Rifampicin-resistant *E. coli* O157:H7 ATCC#700728 was provided by Dr. Linda Harris (University of California, Davis, USA). *L. monocytogenes* (DP-L1044 (hly:Tn917-LTV3) was provided by Dr. Gary Smith (University of California, Davis, USA). All bacteria were stored in liquid nitrogen with glycerol. The stock liquid nitrogen bacteria was streaked onto an LB Agar plate and grown overnight at 37 °C. A colony was picked from the agar plate, and cultured in LB broth for 16 h (*E. coli*) or 24 h (*L. monocytogenes*) to make an initial liquid culture. The initial liquid culture was then sub-cultured in LB broth. In the subculture step, *E. coli* BL21 was either grown for 7 h to reach the stationary growth phase ($\approx 10^{10}$ CFU/mL or OD $\approx$ 1.3 at 600 nm) or grown for 2 h to reach the mid exponential growth phase ($\approx 10^9$ CFU/mL or OD $\approx$ 0.530); *E. coli* O157:H7 was grown for 16 h to reach the stationary growth phase ($\approx 10^9$ CFU/mL or OD $\approx$ 1.4); *L. monocytogenes* was grown for 24 h to reach the stationary growth phase ($\approx 10^9$ CFU/mL or OD $\approx$ 0.4). The exponential

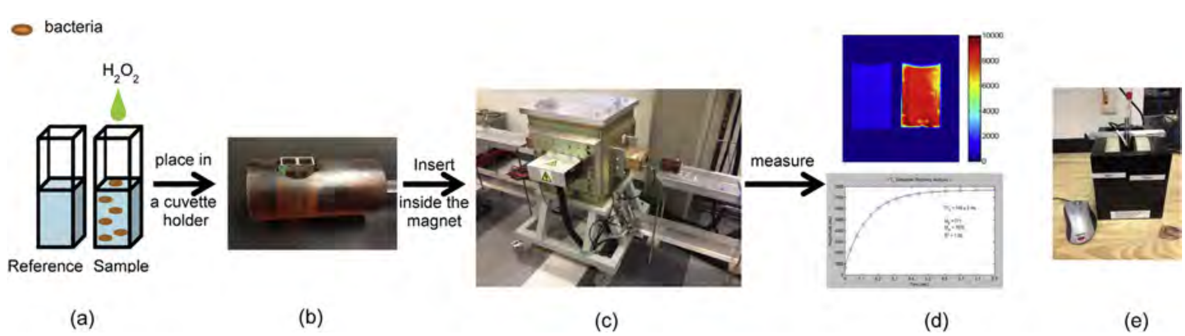

Fig. 1. Illustrates the experimental approach to detect MR contrast based on interactions of bacteria with H_2O_2. (a) The reference (PBS) and bacterial suspension in PBS (sample) were treated with H_2O_2 (b–c) The samples were placed in a cuvette holder and placed inside a 1 T (43.8 MHz) Aspect imaging unit with a 60 mm radio frequency coil (d) Illustrates the representative MR imaging and relaxometry measurements based on interactions of microbes with H_2O_2 (e) Shows an example of a bench top MR relaxometry set up. The size of this system is compared with a standard computer mouse to illustrate portability and compactness of the device.

growth phase and the stationary of the selected bacterial strains were validated by spectroscopic evaluation of the growth curves (data not shown). All the culture media and agar for *E. coli* O157:H7 was supplemented with 50 μg/mL of rifampicin (TCI America, Portland, OR). Before use in each experiment, the bacteria was washed twice with 1× PBS by centrifugation at 3100× g (using Eppendorf Microcentrifuge 5414R) for 10 min at room temperature and resuspended in 1× PBS or LB broth for further analysis.

2.3. Nuclear magnetic resonance imaging

Signal intensity in MR imaging is a function of proton density, spin-lattice relaxation time (T_1), and spin–spin relaxation time (T_2). This study focuses on the T_1 and T_2 relaxation time measurements. These two relaxation time values are affected by the paramagnetic properties of a sample (As, 1992). The T_1 relaxation time describes energy exchange between nuclear spins and their surrounding environment (lattice). The T_2 relaxation time describes energy exchange among nuclear spins.

MR imaging experiments were carried out using a 1 T (43.8 MHz) Aspect imaging unit (Shoham, Israel) with a 60 mm radio frequency (RF) coil. A T_1 weighted Spin Echo 2D (SE 2D) sequence with a repetition time (TR) of 200 ms, an echo time (TE) of 12.8 ms, and a dwell time of 15 μs were used. The number of phase encoding and frequency encoding steps were both 128; the field of view (FOV) was 50 mm. The number of slices was 5, each with a slice thickness of 8 mm. The voxel dimension of 1.22 mm^3 was calculated using the equation below (Eq. (1)).

$$\begin{aligned}\text{Voxel volume} &= \text{phase dimesion} \times \text{frequency dimension} \times \text{slice thickness} \\ &= \frac{\text{FOV}}{\text{phase encoding step}} \times \frac{\text{FOV}}{\text{frequency encoding step}} \times \text{slice thickness} \qquad (1)\end{aligned}$$

MR signal intensity (S) equation for the spin-echo sequence as provided by the Bernstein et al. (Eq. (2)) (Bernstein, King, & Zhou, 2004).

$$S = M_o\left(1 - 2e^{-(\mathrm{TR}-\mathrm{TE}/2)/T_1} + e^{-\mathrm{TR}/T_1}\right)e^{-\mathrm{TE}/T_2} \qquad (2)$$

where M_o is the initial magnetization, TR is the repetition time and TE is the echo time.

Two milliliters of stationary growth phase *E. coli* BL21 at ($\approx 10^{10}$ CFU/mL) were pipetted into a cuvette. After treatment of bacteria with 0–1% v/v of H_2O_2 for 15 min at room temperature with stirring at a frequency of 250 rpm, the sample was placed in a cuvette holder for MR measurements. A reference sample containing 2 mL of PBS was placed next to the H_2O_2 treated sample in a same cuvette holder. The signal intensity of the treated sample was normalized with respect to the reference sample. All the experiments were performed in triplicate. The image files were analyzed using MATLAB™ v7.8.0 (Mathworks Inc., Natick, Mass., U.S.A.).

2.4. Relaxometry

The T_1 and T_2 measurements were acquired in independent experiments with the same MR imaging unit. For the T_1 measurements, a 15 point saturation recovery sequence was used. For the T_2 measurements, a Carr-Purcell-Meiboom-Gill (CPMG) pulse sequence was used with an echo time (TE) of 1 ms.

Two milliliters of bacteria was transferred into a cuvette which was placed in a cuvette holder with an empty cuvette to maintain spatial orientation. Immediately following the addition of 0–1% H_2O_2, changes in the T_1 or T_2 measurements were recorded. Measurements were acquired continuously during the incubation period after the initial 2 min of time required for power and frequency calibration of the instrument. Thus, the time $t = 0$ min as indicated in the result section is after the initial lag of 2 min. All the experiments were conducted in triplicate. The acquired data was analyzed using MATLAB™ v7.8.0.

2.5. Treatment of bacteria with hydrogen peroxide and reduction in culturability of bacteria

Stationary growth phase bacteria (*E. coli* BL21, *E. coli* O157:H7, and *L. monocytogenes*) was treated with 0%, 0.1%, 0.5%, and 1% v/v of H_2O_2; mid exponential growth phase *E. coli* BL21 was treated with 0%, 0.01%, 0.1%, 0.5%, and 1% v/v of H_2O_2. Samples were then incubated for 15 min at room temperature with stirring at a frequency of 250 rpm; 50 μg/mL final concentration of powder catalase was then added to 1 mL mixture of bacteria and H_2O_2 for 10 min to quench activity of the excess H_2O_2 in solution. The treated bacterial cells were washed twice with 1× PBS, plated onto a LB agar overnight, and the bacterial colonies were counted. Each experiment was performed in triplicate.

2.6. Statistical analysis

Statistical analysis of the data was carried out using Microsoft Excel (Microsoft, Redmond, CA). The statistical significance was determined using the t-test, assuming unequal variances with an alpha of 0.05. Results are denoted with asterisks or noted in the text to indicate statistical significance ($^*p < 0.05$, $^{**}p < 0.01$).

3. Results and discussion

3.1. MR imaging contrast induced by interactions of microbes with hydrogen peroxide

Interactions of stationary phase *E. coli* BL21 with H_2O_2 (0–1% v/v) were measured using T_1-weighted MR imaging as shown in Fig. 2. Fig. 2 (a) shows the MR images of stationary growth phase *E. coli* BL21 suspension upon treatment with the selected concentration range of H_2O_2 (0–1%). Quantification of the imaging data (Fig. 2(b)) shows that the relative MR signal intensity in these microbial samples increase as a function of H_2O_2 concentration. The results show significant differences ($p < 0.01$) in the signal intensity between H_2O_2 treated and non-treated *E. coli* BL21 suspensions. An eightfold increase in signal intensity was observed for the *E. coli* BL21 sample treated with 1% H_2O_2 as compared to the control sample (not treated with H_2O_2). Furthermore, significant

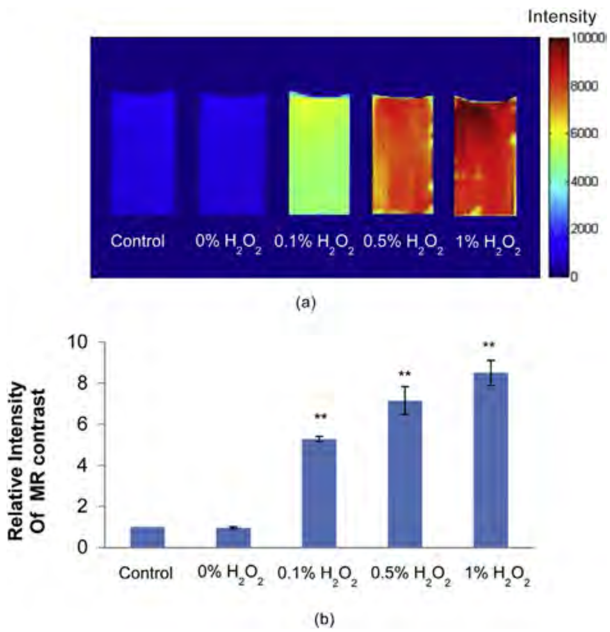

Fig. 2. T_1 weighted MR imaging measurements to characterize interactions of stationary phase *E. coli* BL21 with H_2O_2. The control sample is 1× PBS. (a) Representative MR images to illustrate changes in MR contrast properties of BL21 suspension in PBS as a function of H_2O_2 concentration and (b) Relative quantification of MR signal intensity as a function of H_2O_2 concentration. The data was normalized with respect to the MR signal intensity in the reference sample. The results represent mean value ± standard deviation based on three independent repeat measurements. ($^{**}p < 0.01$ compared to 0% H_2O_2).

differences in MR contrast ($p < 0.01$) between the H_2O_2 treated and control sample (non-treated *E. coli* BL21 suspensions) can be detected at and above the concentration levels of 0.1% H_2O_2. Addition of H_2O_2 to PBS did not show any significant changes in the T_1 weighted MR signal intensity as shown in the supplementary Fig. S1. To the best of our knowledge this is the first observation that indicates microbial interactions with H_2O_2 can induce significant changes in MR contrast properties, compared to the control, and these changes can be detected at concentration levels corresponding to both sub-lethal (0.1%) and lethal (above 0.1%) concentration levels of H_2O_2.

3.2. MR relaxometry to characterize interactions of microbes with hydrogen peroxide

To further characterize changes in the MR contrast induced by biochemical interactions of H_2O_2 with *E. coli* BL21, the T_1 and T_2 relaxation times were measured. MR signal intensity is a function of the T_1 and T_2 relaxation times, and the proton density. Thus, characterizing changes in the T_1 and T_2 relaxation times induced by interactions of *E. coli* BL21 with H_2O_2 could elucidate the potential mechanisms for the observed changes (Fig. 2) in MR contrast properties. Results in Fig. 3 show changes in the T_1 relaxation time as a function of H_2O_2 concentration and incubation time. The results show at least a ten-fold difference in the initial T_1 relaxation time (at 0 min) of *E. coli* BL21 suspension upon treatment with 0.1% v/v H_2O_2 as compared to the control (*E. coli* BL21 suspension in PBS without H_2O_2). Fig. 3 shows that the decrease in the initial T_1 time is a function of H_2O_2 concentration in the range of 0.1–0.5% H_2O_2. With an increase in H_2O_2 concentration above 0.5%, no significant difference ($p > 0.05$) was observed in the initial T_1 measurement. The results in Fig. 3 also indicate that the T_1 relaxation time changes during incubation of *E. coli* BL21 with H_2O_2.

Reduction in the T_1 value can be induced by generation of paramagnetic species, oxygen, upon interactions of microbes with H_2O_2. Biochemical interactions of H_2O_2 with intracellular catalases are known to generate oxygen (Kauczor & Kreitner, 2000; Schellhorn, 1995). In addition, oxygen is a well-known paramagnetic contrast agent. To demonstrate generation of oxygen upon biochemical interactions of microbes with H_2O_2, an oxygen sensitive dye $Ru(BPY)_3$ was added to the aqueous phase of *E. coli* BL21 suspension. The fluorescence intensity of this dye is inversely proportional to oxygen concentration. Result in Fig. S2 shows a significant decrease in fluorescence intensity of the oxygen sensitive dye, indicating that interaction of bacteria with H_2O_2 results in generation of molecular oxygen. The decrease in fluorescence intensity of the oxygen sensitive dye upon interaction of *E. coli* BL21 with H_2O_2 followed a similar pattern as observed for the T_1 relaxation time measurements (Fig. 3), although the dynamic range of fluorescence measurements was less as compared to the T_1 measurement using MR. This result validates that molecular oxygen generated by endogenous enzymatic degradation of H_2O_2 is the key paramagnetic contrast source for the observed changes in MR properties.

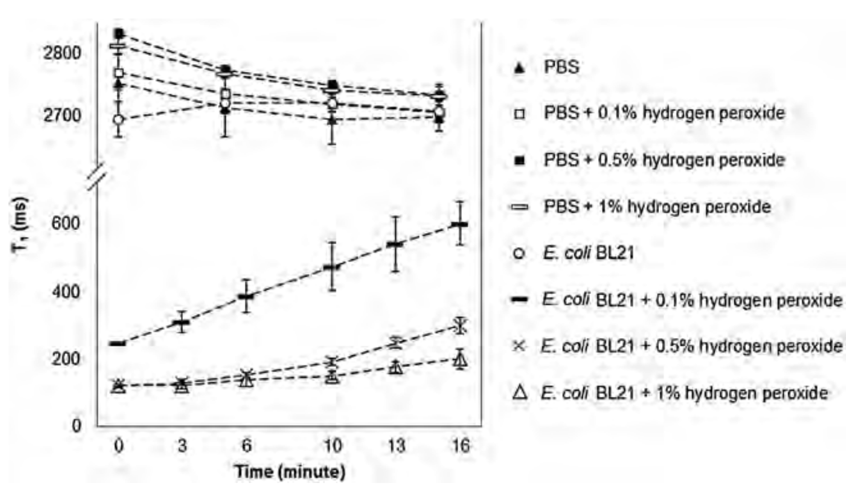

Fig. 3. Changes in the T_1 relaxation time following treatment of microbial suspension (stationary growth phase *E. coli* BL21) with H_2O_2 in PBS. The controls were PBS solutions incubated with different concentration (% v/v) of H_2O_2 and *E. coli* BL21 suspension in PBS without H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements.

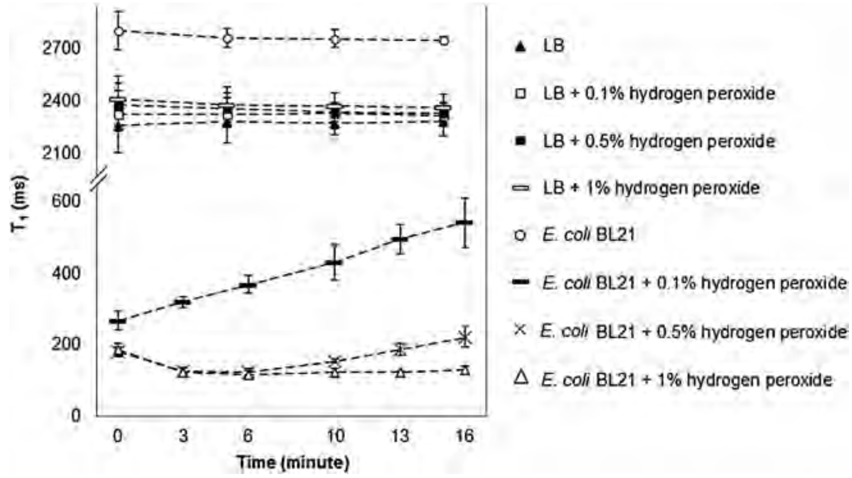

Fig. 4. Demonstrates application of MR measurement approach to measure interactions of stationary phase *E. coli* BL21 with H_2O_2 in presence of organic content (15,000 ppm). Illustrates changes in T_1 relaxation time following treatment of *E. coli* BL21 suspension in LB media with H_2O_2. The controls were different concentrations of H_2O_2 in LB media and *E. coli* BL21 in LB media without H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements. The controls (without bacteria) were based on two independent repeat measurements.

Similar to the trend observed for the T_1 relaxation measurements, the T_2 relaxation time for the stationary phase *E. coli* BL21 suspension treated with H_2O_2 shows significant reduction ($p < 0.05$) as compared to the controls (Supplementary Fig. S3). Reduction in the T_2 relaxation time was also observed to be a function of both H_2O_2 concentration and incubation time. In contrast to changes in the T_1 relaxation time, addition of H_2O_2 to the control PBS solution (without microbes) did induce a relatively small but significant reduction in the T_2 relaxation time. Therefore, T_2 relaxation time may not be influenced only by the biochemical interactions between H_2O_2 and microbes and thus was not investigated further.

3.3. MR relaxometry measurements in the presence of organic load

To illustrate the potential of measuring biochemical interactions of bacteria with H_2O_2 in the presence of organic load using relaxometry, the MR measurements were conducted using the stationary growth phase *E. coli* BL21 in LB broth (a common growth media for microbes with approximately 15,000 ppm of organic content). LB broth was chosen as the model organic load based on a prior study (Park, Hung, Doyle, Ezeike, & Kim, 2001). Fig. 4 shows significant reduction in the initial T_1 relaxation time as a function of H_2O_2 concentration between 0 and 0.5%. The results also show that reduction in the initial T_1 relaxation time reaches a saturation value for H_2O_2 concentration greater than 0.5%, similar to changes in the initial T_1 relaxation time observed for the *E. coli* BL21 suspended in PBS (without organic content) (Fig. 3). These results indicate that MR measurement approach can measure bacterial resistance to H_2O_2 in the presence of organic load.

3.4. Interactions of stationary and exponential growth phase bacteria with hydrogen peroxide

The next objective was to compare the differences in interactions of stationary and exponential growth phase *E. coli* BL21 with H_2O_2 using relaxometry. MR relaxometry measurements (Fig. 5) show that reduction in the initial T_1 relaxation time upon incubation of *E. coli* BL21 with H_2O_2 was significantly smaller ($p < 0.01$) for the exponential phase microbes as compared to that for the stationary growth phase microbes (Fig. 3). For example, at 0.1% H_2O_2, the initial T_1 value for the exponential phase *E. coli* BL21 suspension was 899.0 ± 49.9 ms, whereas the initial T_1 value for the stationary phase *E. coli* BL21 suspension was 248.3 ± 4.7 ms. The

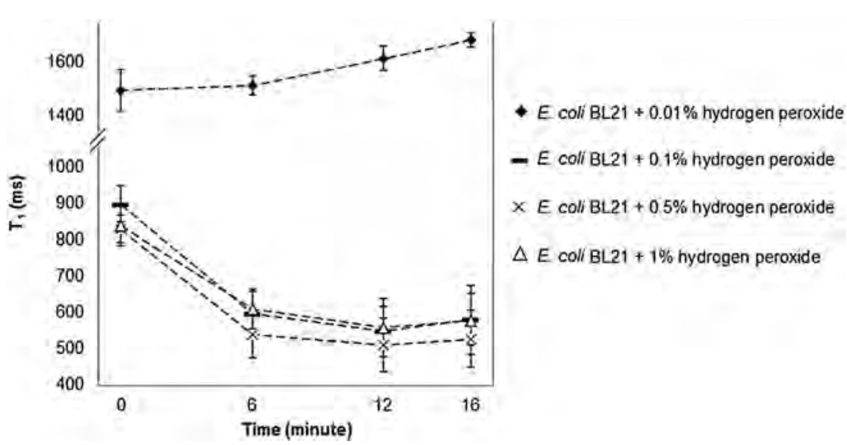

Fig. 5. Changes in T_1 relaxation time following treatment of microbial suspension (exponential growth phase *E. coli* BL21) with H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements.

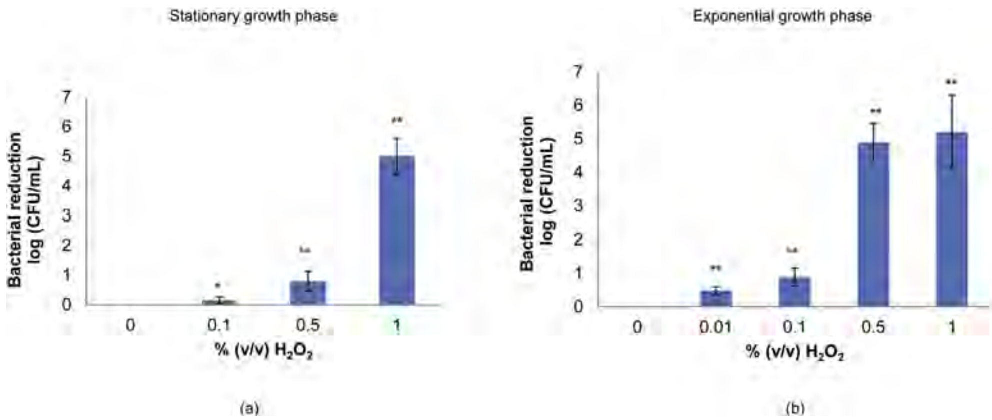

Fig. 6. Measurement of reduction in bacterial count for (a) Stationary growth phase, and (b) Exponential growth phase *E. coli* BL21 upon incubation with different concentration levels of H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements. (*$p < 0.05$, **$p < 0.01$ compared to 0% H_2O_2).

results also show that reduction in the initial T_1 relaxation time for the exponential phase *E. coli* BL21 reaches a saturation value (~900 ms, Fig. 5) for H_2O_2 concentration equal or greater than 0.1%. For the stationary phase *E. coli* BL21, reduction in the initial T_1 relaxation time reaches a saturation value (~120 ms, Fig. 3) only for H_2O_2 concentration levels at and above 0.5%. Together, these results indicate that the stationary phase *E. coli* BL21 can generate significantly higher concentration of molecular oxygen upon interaction with H_2O_2 as compared to the exponential phase *E. coli* BL21. These results indicate that the stationary phase *E. coli* BL21 have significantly higher catalase activity as compared to the exponential phase *E. coli* BL21. This indication based on MR measurements is in

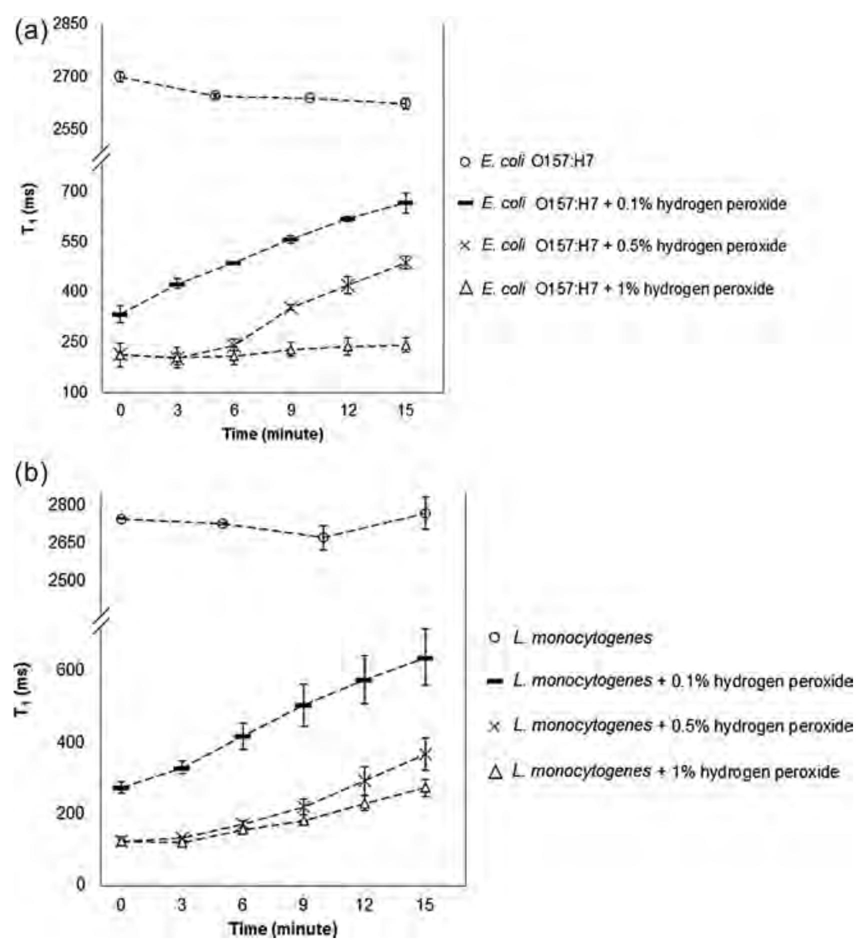

Fig. 7. (a) Changes in the T_1 relaxation time following treatment of stationary phase *E. coli* O157:H7 suspension with H_2O_2 in PBS. The control was *E. coli* O157:H7 in PBS without H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements. (b) Changes in the T_1 relaxation time following treatment of stationary phase *L. monocytogenes* suspension with H_2O_2 in PBS. The control was *L. monocytogenes* in PBS without H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements. The non-treatment results (without H_2O_2) were based on two independent repeat measurements.

agreement with the current literature (Beatriz González-Flecha, 1995; Loewen & Switala, 1986; Schellhorn, 1995). Elevated expression of catalases is one of the key factors responsible for higher oxidative stress resistance of the stationary phase bacteria as compared to the exponential phase bacteria.

3.5. Correlation of MR measurements with reduction in culturability

Bacterial plate counting is the standard approach for measuring reduction in bacterial load following treatment with sanitizers. One of the goals of this study was to correlate the results of MR measurements with reduction in culturability of bacteria following treatment with H_2O_2. Reduction in culturability of *E. coli* BL21 as a function of H_2O_2 concentration is shown in Fig. 6. The results (Fig. 6 (a)) show that in stationary phase *E. coli* BL21, a significant reduction (at or above 4 log) in culturability was observed at H_2O_2 concentration above 0.5%, while for the exponential phase *E. coli* BL21 (Fig. 6 (b)) a significant reduction in culturability was observed at H_2O_2 concentration above 0.1%. These critical levels of H_2O_2 concentration for both the stationary and exponential phase *E. coli* BL21 correspond to the concentration levels of H_2O_2 above which no significant reduction in the initial T_1 relaxation times were observed (Figs. 3 and 5). These critical concentration levels of H_2O_2 for both the exponential and the stationary phase *E. coli* BL21 indicate concentration levels above which the H_2O_2 degrading enzymes (catalase) are saturated. Above these critical concentration levels, the excess concentration of H_2O_2 can induce lethal damage to *E. coli* BL21. Thus, the critical concentration of H_2O_2 that can be degraded by the *E. coli* BL21 is indicative of the resistance of the bacteria. Together, Figs. 3–6 demonstrate that resistance of *E. coli* BL21 to H_2O_2 is a function of physiological state of microbes and is not significantly influenced by organic load (LB broth, 15,000 ppm).

3.6. MR measurements to characterize resistance of E. coli O157:H7 and L. monocytogenes to hydrogen peroxide treatments and its correlation with reduction in culturability

To demonstrate application of the MR approach to detect resistance of both gram-positive and gram-negative bacteria to H_2O_2, stationary phase *E. coli* O157:H7 and *L. monocytogenes* were treated with H_2O_2 under the same set of experimental as described in Fig. 3 (*E. coli* BL21). The results of MR measurements were correlated with reduction in culturability of the selected bacteria.

The results in Fig. 7(a) and (b) shows changes in the T_1 relaxation time upon treatment of stationary phase *E. coli* O157:H7 and *L. monocytogenes* respectively with H_2O_2. The results show that increase in H_2O_2 concentration results in decrease in the initial T_1 relaxation times, similar to the results obtained with the *E. coli* BL21 model system. Furthermore, these results also demonstrate that above a critical concentration of H_2O_2 no significant changes in the initial T_1 value were observed. For both the *E. coli* O157:H7 and *L. monocytogenes*, the critical concentration level was 0.5% H_2O_2. This critical concentration level was same as measured for the stationary phase BL21 model bacteria, although the measured initial T_1 values for each species were different. For example, the initial T_1 relaxation time for the stationary phase *E. coli* BL21 was 120 ms at 0.5% H_2O_2; whereas the initial T_1 relaxation time for the stationary phase *E. coli* O157:H7 was 215 ms at 0.5% H_2O_2. Surprisingly, the T_1 relaxation time for the stationary phase *L. monocytogenes* was similar to the measured T_1 value for the *E. coli* BL21 (124 ms at 0.5% H_2O_2), under the same set of experimental conditions.

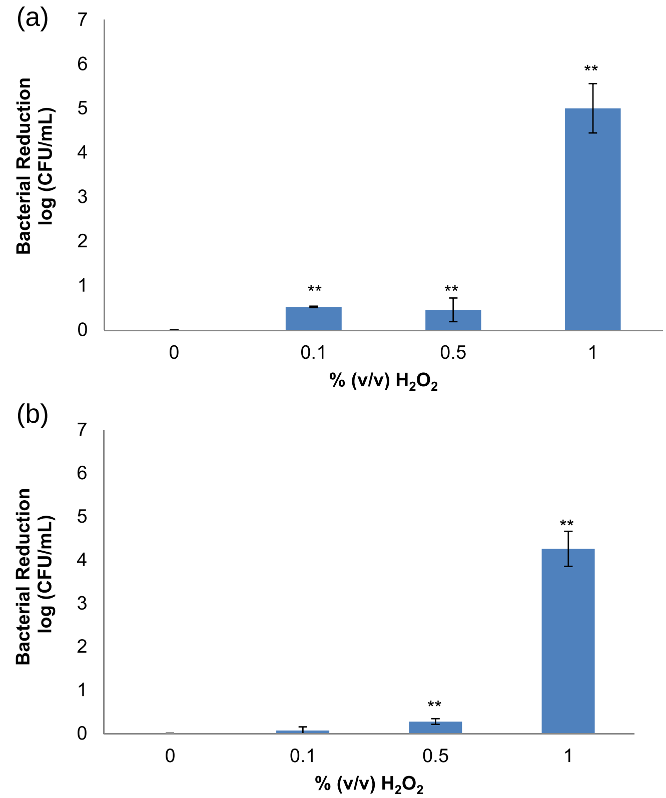

Fig. 8. (a) Measurement of reduction in microbial count for stationary phase *E. coli* O157:H7 upon incubation with different concentration levels of H_2O_2. The results represent mean value ± standard deviation based on at least two independent repeat measurements. (b) Measurement of reduction in microbial count for stationary phase *L. monocytogenes* upon incubation with different concentration levels of H_2O_2. The results represent mean value ± standard deviation based on three independent repeat measurements. (**$p < 0.01$ compared to 0% H_2O_2).

The results in Fig. 8(a) and (b) show the reduction in culturability of the selected strains of bacteria as a function of H_2O_2 treatment. The results show that above 0.5% H_2O_2, a significant reduction in microbial culturability was observed in both *E. coli* O157:H7 and *L. monocytogenes*. This critical level of H_2O_2 concentration for both the stationary *E. coli* O157:H7 and *L. monocytogenes* corresponds to the concentration level of H_2O_2 above which no significant reduction in the initial T_1 relaxation times was observed (Fig. 7(a) and (b)). Overall, these results demonstrate that MR based measurement can determine the critical concentration of H_2O_2 above which significant reduction in culturability can be achieved in gram-positive and gram-negative bacteria expressing catalases. Although the methodology developed in this study is limited to catalase positive organisms, it has significant potential in improving food safety as many of the key food borne pathogenic bacteria including *E. coli* O157:H7, *Salmonella* spp., and *L. monocytogenes* are catalase positive and are important targets of sanitation processes.

4. Conclusion

This study demonstrates the development and validation of a novel label-free MR imaging and relaxometry method to rapidly assess the resistance of *E. coli* and *L. monocytogenes* to H_2O_2. As demonstrated, the degradation reaction results in generation of molecular oxygen (paramagnetic species). The generation of molecular oxygen provides significant MR contrast to measure enzymatic activity of *E. coli* toward both sub-lethal (in the range of

0–0.1% H_2O_2) and lethal levels (above 0.5% H_2O_2) even in the presence of high organic load. This label free approach can detect differences in the resistance of stationary and exponential phase *E. coli* to hydrogen peroxide. In addition, this MR method can determine the critical concentration of H_2O_2 (or resistance of the bacteria) above which a significant reduction in culturability of *E. coli* (BL21 and O157:H7) and *L. monocytogenes* was achieved. The method developed in this study can also be adapted to the currently available MR detection systems in food, chemical, oil, and pharmaceutical industry (Koseki & Isobe, 2005). Based on these unique features, this approach has significant advantage in measuring the efficacy of H_2O_2 toward catalase-positive bacteria in both laboratory and field conditions. It is envisioned that this approach can be used to assess the efficacy of sanitation based on incubation of target bacteria with water samples from sanitation processes. Furthermore, based on the ability of MR imaging and relaxometry to measure changes in relaxation properties in opaque mediums, it is expected that this approach can be extended to semi-solid and solid environments such as soil samples.

Acknowledgments

This work was supported by grant 2013-262 from the Center for Produce Safety.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.foodcont.2014.09.038.

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Attachment for SCB12068

Tables and Figures:

Table 1. *Salmonella* spp. and Shiga toxin-producing *Escherichia coli* (STEC) frequency in (N = 750) and wildlife (N = 1,225) samples, southwestern desert, 2013-2014.

Salmonella	Sample size	Number positive	Percent positive (%)
Cattle	750	52	6.9
Feral swine	53	15	28.3
Javelina*	13	2	15.4
Wild birds	383	8	2.1
Wild rodents/rabbits	776	24	3.1
Non-O157 STEC	**Sample size**	**Number positive**	**Percent positive (%)**
Cattle	750	288	38.4
Feral swine	53	4	7.5
Javelina*	13	1	7.7
Wild birds	383	10	2.6
Wild rodents/rabbits	776	1	0.1
STEC O157	**Sample size**	**Number positive**	**Percent positive (%)**
Cattle	750	130	17.3
Feral swine	53	1	1.9
Javelina*	13	0	0
Wild birds	383	0	0
Wild rodents/rabbits	776	0	0

*Javelina samples collected during 2012 hunter harvest survey.

Table 2. *Salmonella* spp. and Shiga toxin-producing *Escherichia coli* (STEC) frequency in wild birds by species, southwestern desert, 2013-2014.

		Percent positive (%)		
Wild Bird (common name)	Sample size	*Salmonella*	Non-O157 STEC	STEC O157
Black phoebe	1	0	0	0
Brown-headed cowbird	92	1 (1.1)	5 (5.4)	0
Chipping sparrow	1	0	0	0
Common grackle	1	0	0	0
Common ground dove	5	0	0	0
Common raven	4	1 (25.0)	0	0
Common yellowthroat	1	0	0	0
Eurasian collared dove	31	0	0	0
European starling	2	0	0	0
Gambel's quail	8	0	0	0
Great-tailed grackle	21	2 (9.5)	0	0
Green heron	1	0	0	0
House sparrow	5	0	0	0
Loggerhead shrike	3	0	0	0
Mourning dove	5	0	0	0
Pacific slope flycatcher	1	0	0	0
Red-winged blackbird	157	1 (0.6)	2 (1.3)	0
Vesper sparrow	4	0	0	0
Western kingbird	2	0	0	0
White-crowned sparrow	16	1 (6.1)	3 (18.8)	0
White-winged dove	3	0	0	0
Wilson's warbler	2	0	0	0
Yellow-headed blackbird	3	0	0	0
Yellow-rumped warbler	11	1 (9.1)	0	0
Unknown	3	1 (33.3)	0	0
Total	383	8 (2.1)	10 (2.6)	0

Table 3. *Salmonella* spp. and Shiga toxin-producing *Escherichia coli* (STEC) frequency in wild rodents and rabbits by species, southwestern desert, 2013-2014.

		Number positive (%)		
Wild Rodents (common name)	Sample size	*Salmonella*	Non-O157 STEC	STEC O157
Botta's pocket gopher	1	1 (100.0)	0	0
Brush mouse	1	0	0	0
Cactus mouse	272	6(2.2)	0	0
Deer mouse	9	0	0	0
Desert cottontail rabbit	1	0	0	0
Desert kangaroo rat	1	0	0	0
Desert pocket mouse	264	7 (2.7)	1 (0.4)	0
Hispid cotton rat	15	0	0	0
House mouse	21	0	0	0
Long-tailed pocket mouse	18	0	0	0
Merriam's kangaroo rat	37	4 (10.8)	0	0
Rock pocket mouse	5	0	0	0
Round-tailed ground squirrel	12	2 (16.7)	0	0
Western harvest mouse	3	0	0	0
Western white-throated wood rat	114	4 (3.5)	0	0
Unknown	2	0	0	0
Total	776	24 (3.1)	1 (0.1)	0

Table 4. Seasonal pathogen of *Salmonella* spp. and Shiga toxin-producing *Escherichia coli* (STEC) in cattle, wild bird, and wild rodent samples (seasonal peaks are highlighted in **bold**).

Salmonella	Spring	Summer	Fall	Winter
Cattle	2.5%	0.0%	**16.5%**	9.3%
Wild Birds	**3.7%**	0.0%	1.3%	1.7%
Wild Rodents	3.3%	2.0%	**3.4%**	3.3%

Non-O157	Spring	Summer	Fall	Winter
Cattle	32.0%	22.5%	**52.5%**	49.3%
Wild Birds	**5.9%**	0.0%	1.3%	0.0%
Wild Rodents	0.0%	0.7%	0.0%	0.0%

E. coli O157	Spring	Summer	Fall	Winter
Cattle	9.0%	**22.5%**	20.0%	18.0%
Wild Birds	0.0%	0.0%	0.0%	0.0%
Wild Rodents	0.0%	0.0%	0.0%	0.0%

Table 5. Birds fitted with radio-transmitters by season.

Common Name	Spring	Summer	Fall	Winter	TOTAL
Brown-headed cowbird	6	0	1	4	11
Common raven	3	0	0	1	4
Eurasian collared dove	6	0	14	1	21
European starling	1	0	0	0	1
Red-winged blackbird	27	0	34	5	66
TOTAL	43	0	49	11	103

Table 6. O-serotype frequency among Shiga toxin-producing *Escherichia coli* (STEC) isolates obtained from cattle (N = 750) and wildlife (N = 1,225) samples in the southwestern desert (isolates belonging to the "top 7" clinically relevant serogroups are shown in **bold**).

		Source				
O-antigen	**Cattle**	**Feral swine**	**Javelina**	**Wild bird**	**Wild rodent**	**Total**
1	2	0	0	0	0	2
103	**3**	**1**	**0**	**0**	**0**	**4**
108	1	0	0	0	0	1
109	15	0	0	0	0	15
111	**1**	**1**	**0**	**0**	**0**	**2**
115	1	0	0	0	0	1
136	38	1	1	0	0	40
145	**5**	**0**	**0**	**0**	**0**	**5**
149	3	0	0	0	0	3
156	29	0	0	1	0	30
157	**130**	**1**	**0**	**0**	**0**	**131**
160	11	0	0	2	0	13
163	1	0	0	0	0	1
168	3	0	0	0	0	3
171	16	0	0	0	0	16
178	8	0	0	0	0	8
2	14	0	0	0	0	14
22	0	1	0	0	0	1
26	**3**	**0**	**0**	**1**	**0**	**4**
3	1	0	0	3	0	4
41	1	0	0	0	0	1
45	**1**	**0**	**0**	**0**	**0**	**1**
49	1	0	0	0	0	1
5	0	0	0	1	0	1
74	3	0	0	0	0	3
76	2	0	0	0	0	2
8	2	0	0	0	0	2
82	1	0	0	0	0	1
84	1	0	0	0	0	1
85	1	0	0	0	0	1
Untypable	15	0	0	0	0	15
pending	105	1	0	2	1	109
Total	418	6	1	10	1	305

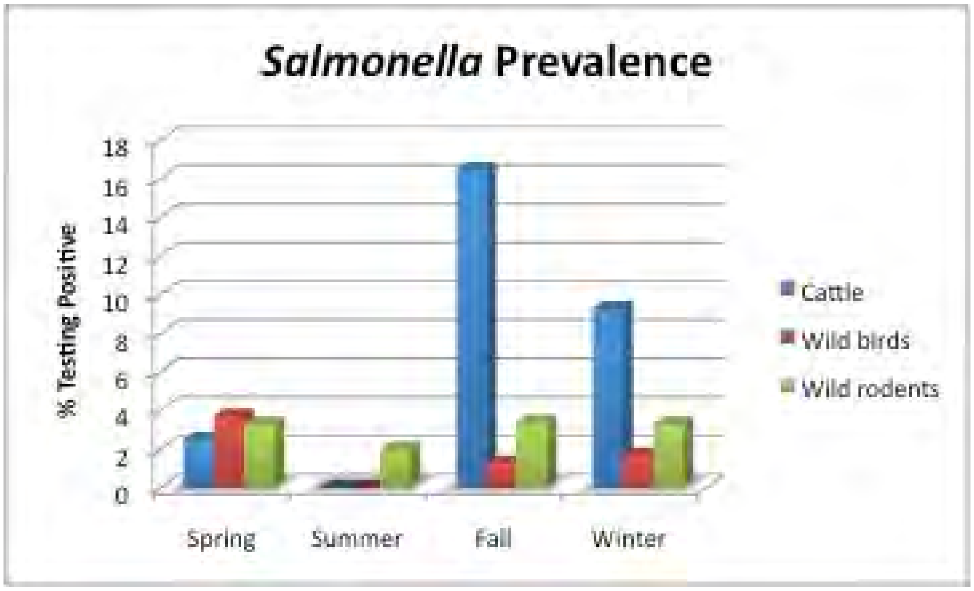


Figure 1. Recovery of *Salmonella* by season from cattle, wild bird, and wild rodent samples in the desert southwest, 2013-2014.

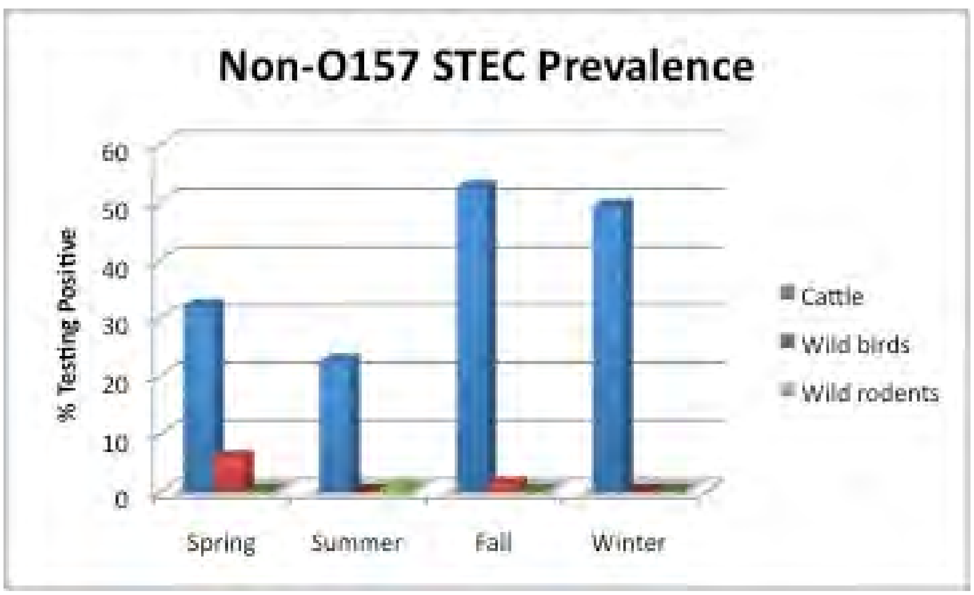


Figure 2. Recovery of non-O157 STEC by season from cattle, wild bird, and wild rodent samples in the desert southwest, 2013-2014.

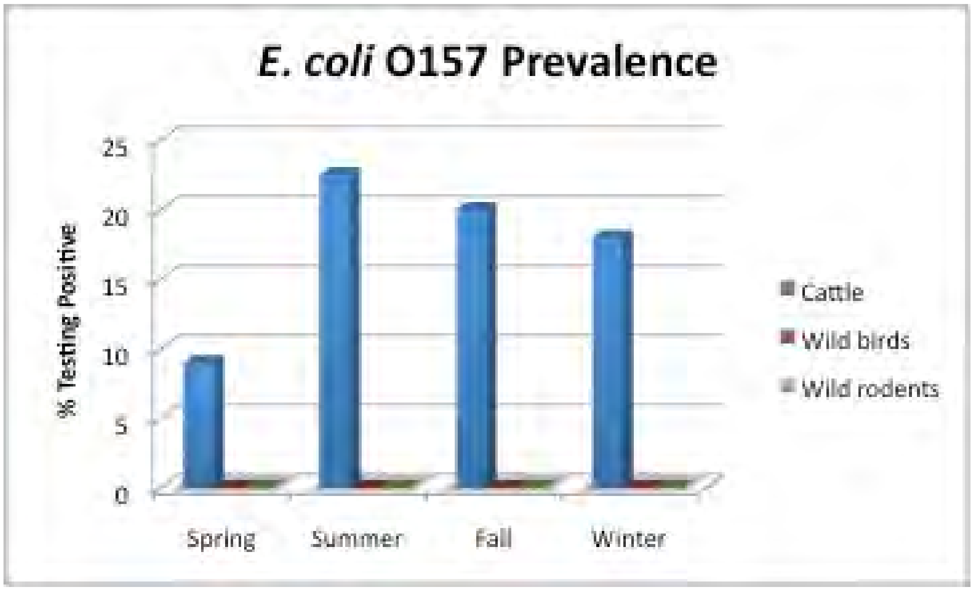


Figure 3. Recovery of STEC O157 by season from cattle, wild bird, and wild rodent samples in the desert southwest, 2013-2014.

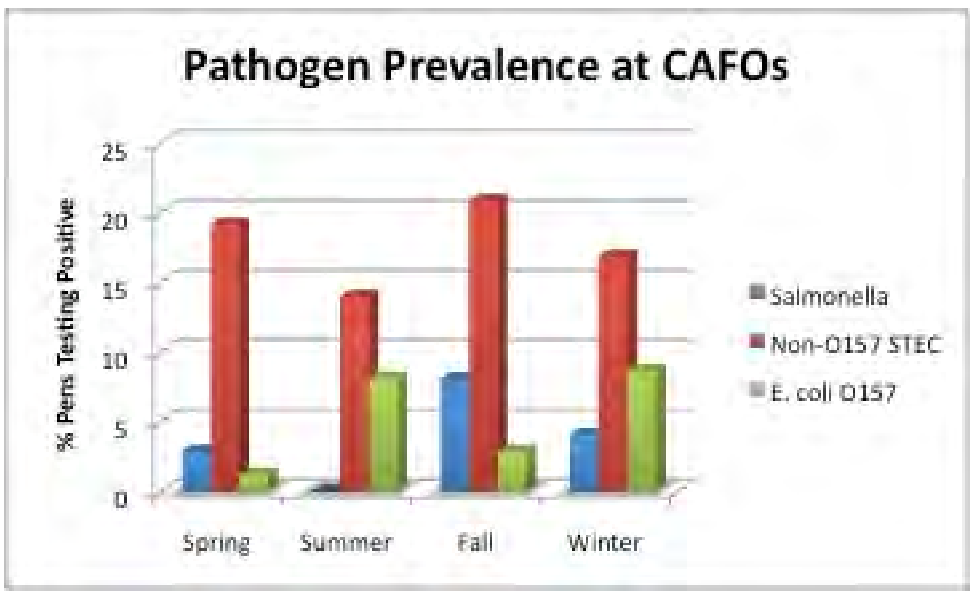
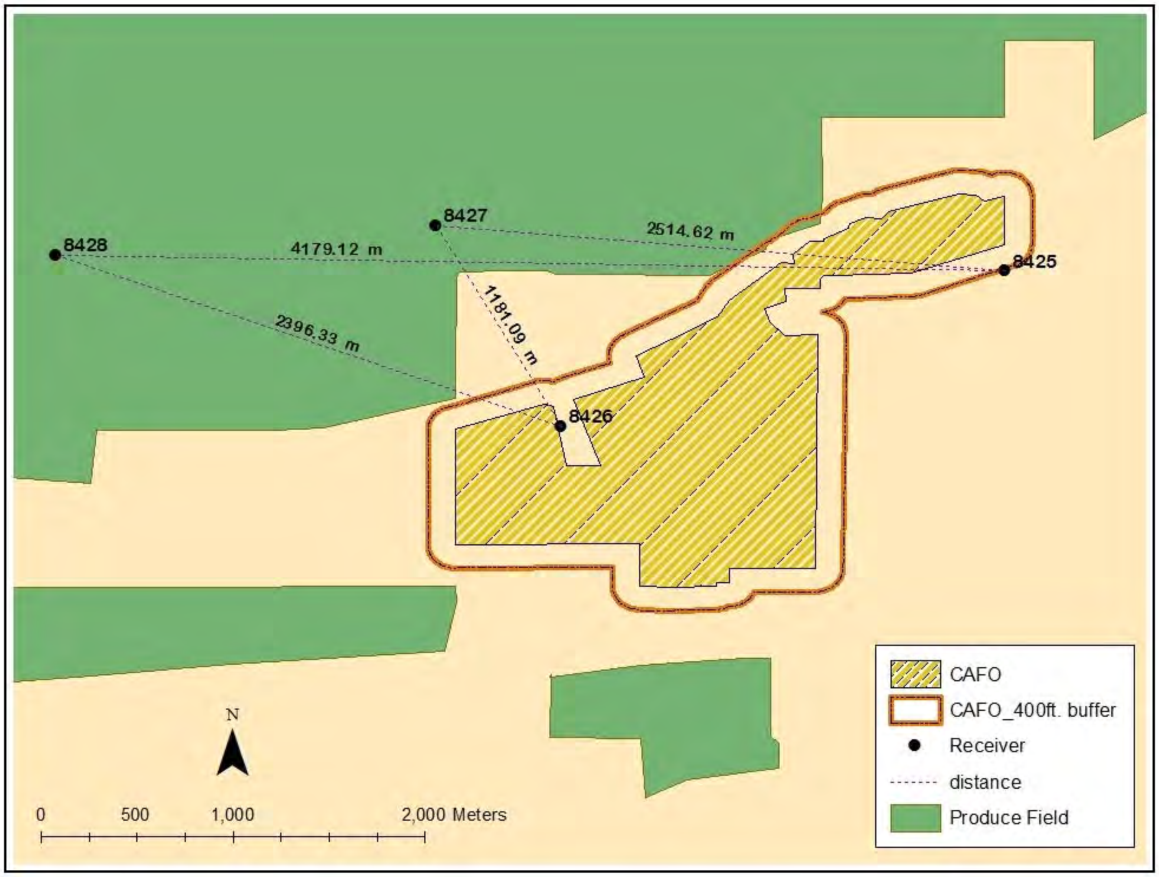


Figure 4. Pathogen prevalence by season in cattle feces at concentrated animal feeding operations (CAFOs), southwestern desert, 2013-2014.

Figure 5. Use of radio-telemetry to track bird movement: (A) solar-powered receiver; (B) bird fitted with a transmitter; (C) "backpack" with transmitter on a red-winged blackbird.



Sources: Esri, DigitalGlobe; AZ Geospatial Data Maps: Major River, Main Stem, Primary & Secondary Tribs; US Census Bureau: TIGER/Line Shapefile, 2013, state, Arizona, Primary and Secondary Roads State-based Shapefile

Figure 6. Map showing the CAFO (Arizona) in yellow, and including all the locations where livestock (cattle) are maintained in pens. The orange line surrounding the CAFO shows the 400ft buffer zone, the minimum area away from livestock that current guidelines recommend that fresh produce intended for human consumption not be planted. The green areas indicate fresh produce fields where the product is intended for human consumption. The black circles represent receivers that record bird movements. Receivers 8425 and 8426 are located at the CAFO, while 8427 and 8428 are located in fresh produce fields between 1 and 4 km away from the CAFO.