Horticulture

CIRAD Highlights

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Introduction

Illustration of the pillars for action

The activities conducted these passed years by CIRAD — the Department Flhor— illustrate the four pillars for action mentioned in introduction. The following description of some scientific activities is not exhaustive: each poster represents an example of CIRADs research, in most of the cases in scientific co-operation.

1 Food, nutrition and health

2 Risk assessment and management

3 City food and service supply

4 High added value products

Introduction

Horticulture is now recognized as a driving force addressing major challenges of the developing world, such as nutrition, poverty alleviation and income generation. For more 50 years, the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) focuses its efforts towards tropical horticulture as a tool for economic and social prosperity in developing countries and tropical overseas regions. The Tropical Fruits and Horticultural Crops Department of CIRAD concentrates its research activities around four thematic axes, strongly supporting the issues addressed for sustainable development, in the line of the Millennium Development Goals (poverty alleviation, reducing hunger, improved health, sustainable environment and activities...):

- Tropical Horticulture for food and health: food security, food safety and impact on health of fruits and vegetables consumption; health value of tropical fruits and vegetables, and impact of technical practices on this effective value.

- Assessment and management of sanitary and environmental risks linked to Tropical Horticulture: impact on environment and food safety of cropping systems, conditions for access to markets, emerging and invasive pests and diseases.

- City food and service supply: horticulture as a link between urban and rural areas, and more than a food provider.

- Improving, preserving and sharing the high added value of tropical horticultural products: income and employment generation, improved wealth and well-being.

Tropical horticulture, food, nutrition and health

Fruits and vegetables are the major sources of micronutrients that are essential yet lacking in the diets of half of the world's population. More than single individual compounds, amongst which vitamin A, C, D, iron or selenium, fruits and vegetables are recognized for having preventive effects and regulatory properties against heart diseases, digestive cancers, type II diabetes or obesity, as well as to overcome immunity or mineral deficiencies like anaemia or eye macular degeneration. A first step is the chemical characterization of the fresh horticultural products and the delivery of a comprehensive feature of the nutritional value of fruits and vegetables due to their interaction with the food diet (fibres, lipids, anti-nutritional factors). A second step focuses on the impact of practices, from farm to fork, such as storage, packaging, food processing and culinary practices, on the nutritional status and value of the products. A third step, shred with industrial and medical partners is to evaluate the nutritional and preventive impact of fruits and vegetables, in relation with health and well-beeing. A constant link between farmer's practices and consumer's demands is provided by the long-term experience of CIRAD's staff and network in the tropics.

CIRAD's international layout on tropical horticulture

– Montpellier: genetics, transformation and processes, observatory on international markets
– Reunion Island: IPM, epidemiological survey and eco-physiological study on fruit quality
– French West Indies: environmental impact of horticultural practices, sustainable cropping systems

International scientific cooperation based on outreach programmes with national focal points:
– Vietnam: markets and city supply
– Cameroon: cropping systems
– Latin America: technological processes

Risk assessment and management in tropical horticulture

Horticultural productions are most of the time risky ones. They have to take into account simultaneously phytosanitary risks, biodiversity management, market laws and food safety all along the commodity chain. The tropical horticultural cropping systems are known for some negative environmental impacts due to high use of fertilizers and pesticides. Horticultural risk management is addressing to main issues: reducing pesticide and fertilizer impacts on food safety and environment, and early detection and management of emerging and invasive pests and diseases.

In this line, CIRAD's main scientific objectives are:
– to develop a comprehensive feature of the cropping system ruling, based on scientific approaches of sustainable systems, on knowledge and know-how integrating methods,
– to develop new technologies for epidemiological survey and anticipating phytosanitary disruption, encouraging networking at regional and international levels,
– to elaborate new on-field and post-harvest practices to reduce the use of chemical inputs, applying the principles of Integrated Pest Management (IPM) and Integrated Fruit Production (IFP) for tropical fruits and vegetables.

To check the biodiversity losses, due to genetic erosion and land pressure, the main issues for tropical horticultural crops are to characterize and valorise genetic resources, for improving the resistance of plants and crop systems to biotic or abiotic stress (disease, pest, soil salinity...) and developing specific flavour, colour and/or nutrient contents.

The markets of tropical fruits and vegetables are competitive and fragile. To face marketing risks and catch the opportunities (niche markets), CIRAD is continuously enriching specific databases and improving econometric methods adapted to these markets as well as elaborating specifications for labelled products.

Our strategy for risk assessment and management in tropical horticulture is based on the integration of multidisciplinary knowledge all along the food chain: from the producers to the consumers, and from the field conditions to the market trends.

City food and service supply

More than fifty per cent of the world population is now living in cities, with a high urbanizing rate. That leads to the growth of urbanized areas, competition for natural (land, water) and human resources, and to new demands and priorities towards food and environment. CIRAD's vision is to address these requirements as new opportunities for horticulture, as its perishable products must be produced close to the cities, through intensive cropping systems that are constrained by space and market.

Three output-oriented R&D topics are implemented:
– Market driven production: small scale farmers still have a place and an access to the market if their products meet a demand. Our objective is to develop methods and skills to analyse the demand, to convert it into farming, trading or marketing recommendations, and to generate and organize information flows and tools.
– Food quality and safety: these consumers' requirements are connected to supply, freshness and diversity. Education and capacity building on one hand, information and control systems acknowledged by the stakeholders on the other hand, are the main strategic tools to target this topic.
– Multifunctional role of horticulture: horticulture is not only a food provider to cities, it also provides job employment and opportunities to women, to low educated people and the poorest population, as well as to the richest one. It is essential to include and consider horticulture in the urbanizing strategy, as environmental moderator and as socio-economic factor. CIRAD has developed methodologies through African and South-East Asian partnership, and shares its experience and interest on peri-urban horticulture with cities of emerging and developed countries.

CIRAD's specificity: the total food chain approach

Essential to keep a visibility and a strong link to the stakeholders involved in horticulture, CIRAD's commodity chain approach is organized according to three entries:
– Bananas, plantain and pineapple,
– Tree fruit crops,
– Vegetables and spices.
For each entry, you may find the specialist to answer your questions or address your problems: breeding and genetics, cropping systems, pest and disease management, post-harvest and market-oriented studies. Such an approach allows CIRAD to cover export, regional and local market production requirements as complementary tools for global sustainable development.

Priority commodities: *Musa* spp., *Citrus* spp., fruit diversification (cashew nut, litchi, papaw), mango, pineapple, *Solanaceae* spp., *Vanilla* spp.

High added value products from tropical horticulture

Tropical horticultural products are considered as high added value crops compared to staple food or commodity crops. Added value is stimulated by the local or regional "fresh markets", by exports, by quality standards, by post-harvest processing, by information systems, leading to technological or organizational innovations fitting market demands. These initiatives are mainly driven by the private sector and generate intensive employment.

Research objectives aim at answering three key questions:
– how to promote added value in the value chain?
– how to fairly share added value all along the value chain?
– how to sustain added value in a competitive context?
CIRAD aims at proposing, promoting and transferring new technologies and processes leading to innovative practices new products and market analysis, with specific and valuable characteristics recognized by quality traits (organic product, label, geographic origin). The innovations take into account the agronomical and technological aspects as well as the organizational, commercial and social elements along the commodity chain: producers' association, distribution network, negotiation processes and contracting types.

Considering these four pillars for action, CIRAD cannot afford alone successful projects and expertise. An opened partnership and networking with all the other horticultural research centres, at national, regional and international scales is a key issue. In a global and integrating approach, CIRAD is ambitioning to play a driving role in mobilizing European horticultural forces to implement research programmes at any international level.

Food, nutrition and health

The fruits of Amazonia: biodiversity to be explored for new uses

Dominique Pallet
Prosper, Cendotec-Ipen, Av. Prof. Lineu Prestes
2242 Cidade Universitária,
05508-000 São Paulo SP, Brésil
pallet@cirad.fr

Extraction of açaí pulp.

The Amazon basin is rich in fruit and oil plant genetic resources. Use of these is a major issue for the region. Generally collected using extractivism, numerous fruits have remarkable micronutrient compositions. They possess undeniable assets for use in the present context of healthy, functional and natural foodstuffs.

A few promising fruits

Mainly because of their special composition, we study the following species that are common in the eastern Amazon zone.

- Brazil nut (*Bertholletia excelsa*, Lecythidaceae): a traditional extractivist product in Amazonia.
- The açaí palm (*Euterpe oleracea* and *Euterpe precatoria*, Arecaceae): much appreciated by the inhabitants of Amazonia, it is engaged in an exploitation and consumption process.
- The buriti palm or 'palmier bâche' in Guiana (*Mauritia flexuosa*, Arecaceae): it has a strong orange colour.
- The camu-camu (*Myrciaria dubia* (H.B.K.) and *Myrciaria* sp., Myrtaceae): with small red berries, this grows in flooded areas.

A few lines of research for the use of Amazonian fruits

- Knowledge of biodiversity: botanical differences should be correlated with composition characteristics.
- Post-collection techniques: the setting up at the collection sites of infrastructure and basic techniques such as sorting, storage and drying to build up the quality of the end-product.
- Appropriate processing technology. The processing techniques used for both pulp and oil extraction are ancestral. Technologies tried and tested in other contexts and adapted to the environment should be installed.
- Technico-economic verification of the finished products: it is planned to extract anthocyanins and carotenoids for use as natural colorants. These must have original tones, be stable and be produced using an economically viable extraction method.

The advantages of Amazonian fruits

- Conservation type extractivism: the collection of fruits and oil plants does not endanger the survival of the tree or the species.
- A 'green' image. The fruits and oil plants from the forest have an ecologically correct image and benefit from an entirely organic mode of production.

Açaí and buriti pulp

- Micronutrient compositions are remarkable, with very high antioxidant levels (Table 1).
- New, exotic flavours: the taste of açaí and cupuaçu pulp deserve to be known, for example.

Drying Brazil nuts

Table 1. Antioxidant composition of several fruits.

Fruit	Antioxidant	Antioxidant content	Reference values
Brazil nut	selenium	120 ppm	Half a nut contains the recommended daily intake
Açaí	Anthocyanins	100-200 mg in 100 g juice	Redcurrant: 100-400 mg in 100 ml juice Blackberry 350 mg in 100 g fruit
Buriti	Caroténoïdes	carotenoids 300-400 mg in 100 g pulp	Apricot: 2.5 mg in 100 g Carrot: 10-40 mg in 100 g
Camu-camu	ascorbic acid	1 000-2 000 mg in 100 g	Twenty times as much as in orange

Conclusion

The use of fruits and oil plants from Amazonia is subject to the development constraints in the region, and especially the ecological and logistic aspects. Their biodiversity is little used out of context but new market opportunities are emerging for these products: function foods, organic foods, etc. Know-how and technologies for post-collection, logistics and processing remain to be developed to meet such demand.

CIRAD
Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles

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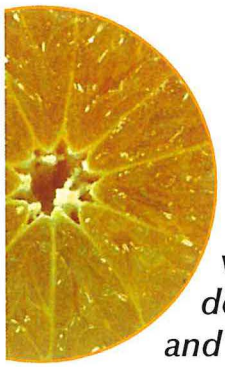
Varietal and interspecific influence on carotenoid content in *Citrus* from Mediterranean area

C. Dhuique-Mayer[1]*, C. Caris-Veyrat[2], P. Ollitrault[1], F. Curk[3], M.J. Amiot[4]

[1] Technologie des fruits, CIRAD-FLHOR, TA50/PS4, 34398 Montpellier Cedex 5, France
[2] Laboratoire des antioxydants naturels, UMR A408, 84914 Avignon Cedex 9, France
[3] Station de recherches agronomiques INRA-CIRAD, 20230 San Giuliano, France
[4] Equipe Vitamines et microconstituants lipophiles, INSERM U476 / INRA U1260 13385 Marseille Cedex 5, France
claudie.dhuique-mayer@cirad.fr



Citrus fruits are especially rich in various antioxidant phytochemicals (vitamin C, polyphenols and carotenoids) that could contribute to their beneficial effects against degenerative diseases. In order to specify the genotypic variation of Mediterranean Citrus juices, carotenoid content was determined for eight orange varieties and mandarin species.

Materials and methods

Selection of orange varieties and mandarin species (*Citrus sinensis* L. Osbeck, *Citrus deliciosa* Ten, and *Citrus clementina* Hort.ex Tan) from Mediterranean area was evaluated by HPLC analysis. Representative samples (15 fruits) harvested during the 2003 season from Agronomic Research Station (Corsica Island) were collected , *Citrus* fruits were hand-squeezed, filtered and kept frozen (– 20°C) until analysed. Carotenoid extraction was carried out according to Taungbodhitham *et al.* (1998). Statistic analysis was used to develop models for classifying the juices in appropriate groups.

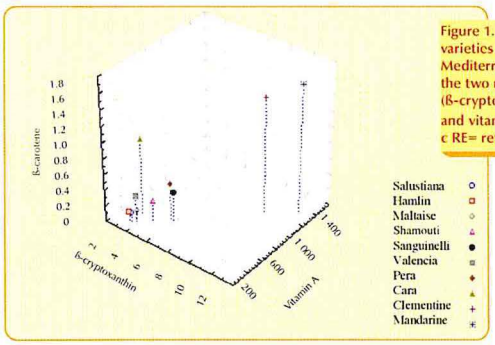


Figure 1. Differentiation of Citrus varieties and species from Mediterranean origin according to the two main carotenoids (ß-cryptoxanthin and ß-carotene) and vitamin A[c] values (a,b mg · L^{-1}; c RE= retinol equivalent).

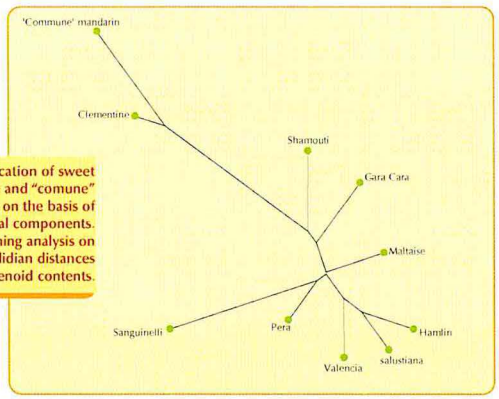


Figure 3. Classification of sweet oranges, clementine and "comune" mandarin on the basis of nutritional components. Neighbour joining analysis on Euclidian distances from carotenoid contents.

Results and discussion

- Mandarin species and two cultivars of oranges, Pera and Sanguinelli displayed a high content in provitamin A carotenoid mainly due to the ß-cryptoxanthin content (1154 mg · L^{-1}, 960 mg · L^{-1}, 374 mg · L^{-1}, 381 mg · L^{-1}, respectively) (figure 1).
- Principal component analysis gave informations on the differentiation of Mediterranean orange varieties and mandarin species based on nutritional criteria (figure 2). Strong correlations were observed between ß-cryptoxanthin and ß-carotene (r = 0.98) and between zeaxanthin and lutein (r = 0.94). Mandarin and orange groups were distinct. Orange varieties could be divided in two groups: the first one with Pera, Sanguinelli and Valencia which displayed a higher content in ß-cryptoxanthin and zeaxanthin and the second including the four others cultivars showing lower carotenoid content.
- Diversity tree allowed to get a genetic approach in order to differentiate *Citrus* cultivars on Euclidian distances (figure 3). This representation showed that hybrid clementine was nearer of its parent mandarin than its parent orange, suggesting that ß-cryptoxanthin was a dominant genetic factor as previously supposed by Goodner *et al.* (2001).

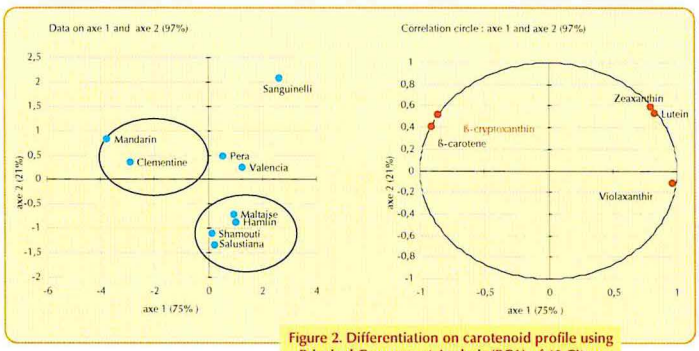


Figure 2. Differentiation on carotenoid profile using Principal Component Analysis (PCA) of 10 Citrus cultivars. Among Citrus cultivars tree distinct groups were observed. PCA gave informations on the differentiation of Mediterranean orange varieties and mandarin species based on nutritional criteria.

Conclusion

This study allowed to make a varietal selection on nutritional criteria for *Citrus* growing in Mediterranean area. Pera and Sanguinelli cvs. appeared particularly interesting among sweet oranges while clementine and mandarin displayed the highest values of provitamin A. Mediterranean mandarin seemed to be promising as parent for nutritional breeding.

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Taungbodhitham A.K., Jones G.P., Wahlqvist M.L., Briggs D.R. (1998) Evaluation of method for the analysis of carotenoids in fruits and vegetables. *Food Chem.* 63, 577-584.

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Centre de cooperation internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles

Fresh cut mangoes: evaluation of edible coatings

Marie-Noëlle DUCAMP-COLLIN[1], M. FREIRE Jr [2], M. REYNES[1], and M. LEBRUN [1]
[1] Cirad UR « Qualité des aliments tropicaux »
TA 50/PS4, bd de la Lironde, 34398 Montpellier cedex
[2]Embrapa Food TechnologyAv das Américas,
29501 Rio de Janeiro, RJ – Brazil
ducamp@cirad.fr

Very little is known about the physiological behavior, poten tial shelf life and quality changes of fresh-cut mangoes. Investigations about the use of edible films in fresh-cut mangoes are still lacking. Therefore, the aim of this work was to evaluate the use of edible coatings to preserve the quality of this product stored under refrigeration, by analyzing some physic-chemical, sensorial and microbiological characteristics.

Raw material

Mangoes (*Mangifera indica* L.) cv. Kent from Ivory Coast cleaned and washed in a 200 ppm chlorine solution and were manually sliced with a sharp knife, cut in pieces (2 x 2 cm) and immersed in 40 ppm cold chlorine water (5°C).

Edible coatings

The mango pieces were dipped for two min in the cold-coated solution, drained and placed on a 0.5 L polypropylene plastic tray (130 to 140 g/tray). Trays were sealed with polypropylene film (thickness 40µ) and stored at 4°C for up to nine days.
Four treatments were evaluated:

- T1: Distilled water was used as a control treatment.
- T2: 1% Sodium Carboxy Methyl Cellulose (CMC) + 0.5% citric acid + 0.05% estearic acid + 0.5% ascorbic acid;
- T3: 0.75% Chitosan + 3% citric acid;
- T4: 1% Dextrin potato starch + 1% calcium lactate + 0.5% ascorbic acid.

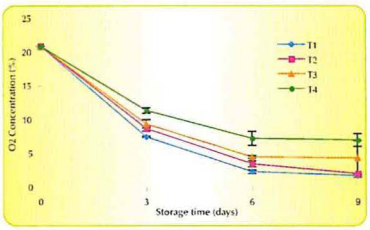

Figure 1. O_2 concentration in the packages of fresh-cut treated mangoes, storage at 4°C

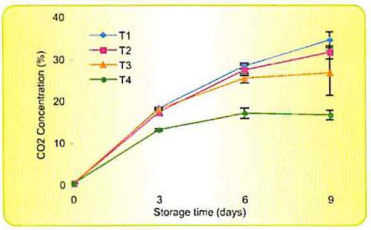

Figure 2. CO_2 concentration in the packages of fresh-cut treated mangoes, storage at

Analytical procedures

O_2 and CO_2 concentrations were measured by withdrawing air samples through a gas analyser Checkmate 9900 PBI (Dansensor Danemark).
Sensorial evaluations: appearance (color) and texture (firmness) analysis. Colour (L^* and b^* values): Minolta CR-300 Chromameter (Minolta, Japan). Ten pieces per replicate were evaluated from each treatment.
Firmness: Texture Analyser TA-TX2 (Texture Technologies Corp., Scarsdale, NY, USA) with a system of inox probe (2 mm diameter) with the insert distance of 10mm.

Results

Chitosan and Dextrin treatments showed a continuous decay up to 4% and 7% for Oxygen levels
The CO_2 levels increased more rapidly in control and CMC treated fruits than in Chitosan and Dextrin
The firmness results showed no difference between the treatments. During all the storage period, the firmness variation coefficient of the samples ranged from 40% to 50% (Figure 3).
After nine days of storage at 4 °C, fresh-cut mangoes treated with Chitosan resulted in better visual quality, the maintenance of yellow colour (value L^* and b^* more positive) and fewer symptoms of browning and decay, followed by CMC treatment (figure 4)
Respiratory rate decreased when chitosan coating is used (table 1)

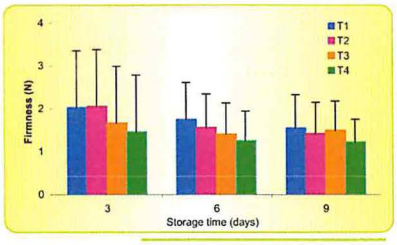

Figure 3. Firmness of fresh cut treated mangoes, stored at 4 °C.

Table 1. Changes in respiratory intensity (IR O_2 and IR CO_2) and respiratory coefficient (RQ) for fresh cut mangoes treated with coatings and storage at 23°C.

Products	T (°C)	IR O_2	IR CO_2	RQ
Mature mangoes	23	1.50	3.92	2.61
Control	23	1.34	2.29	1.71
Carboxy methyl cellulose	23	1.19	2.02	1.70
Chitosan	23	1.24	1.71	1.38

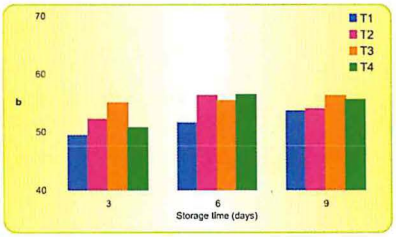

Figure 4 Colour (b* value) of the treated mangoes storage at 4°C.

Conclusion

According to the results obtained in this study, the chitosan treatment shows the best results in comparition with the other treatments after nine days of storage at 4°C and it could be used to maintain the quality of fresh-cut mangoes without detrimentally affecting physico-chemical and sensorial characteristics.

Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles
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The quality of orange juice produced by tangential microfiltration and osmotic evaporation

M. Cisse, F. Vaillant, A. Perez, M. Dornier, M. Reynes*
** Cirad, Cita, Universidad de Costa Rica*
2060 San José, Costa Rica
vaillant@cirad.fr

Orange juice microfiltered and then concentrated to 42° Brix and 62° Brix.

Orange juice concentrated to 62° Brix, whose quality is very similar to that of flash-pasteurised juice (F), was prepared by the combining in series, in a semi-industrial pilot installation of two athermal processes, tangential microfiltration (TMF) and osmotic evaporation (OE) (Figure 1).

The extraction process

The first technique was implemented using a tubular ceramic membrane with 0.2 micron pore diameter; this separated a pulpy juice (R) that contained more particularly the apolar aromatic and nutritional compounds (terpenic hydrocarbons and carotenoids) and sterile clarified orange juice (P) containing the greater part of the more heat-sensitive compounds (aliphatic alcohols, esters, aldehydes, terpenols and vitamin C) (Table 1). The proportion of retentate to clarified juice (permeate) was 70% and 30% with average filtration flows of some 60 l.h-1.m-2; this is compatible with industrial use. The permeate (P) was then concentrated in a pilot OE installation (Figure 2) consisting of a hydrophobic membrane that establishes a layer of air that cannot be penetrated by the liquid between the two compartments, one containing the clarified juice to be concentrated and the other highly saturated calcium chloride brine.

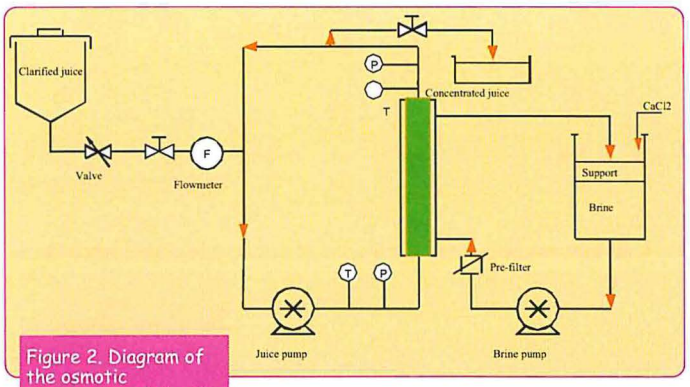

Figure 2. Diagram of the osmotic evaporation pilot unit.

This makes it possible, at room temperature, to extract the water that flows through the pores in vapour form and condenses on the brine side. Even though the characteristics of the membrane used for this application could be improved considerably, average flows of 0.6 kg.h-1.m-2 water are attained, making possible continuous extraction for several hours of an average flow of 150 ml.h-1.m-2 of concentrated juice at 62° Brix ($C_{62°Brix}$ OE), while feeding the pilot installation with a flow of 0.75 l.h-1.m-2 with clarified juice (P).

Juice quality

The aromatic and nutritional characteristics of the concentrated juice produced are very similar to those of the initial juice (F) and indeed a trained panel cannot perceive a significant difference at the same dilution. A pulpy orange juice (C62° Brix OE + R) reconstituted by mixing the concentrated clarified juice and the

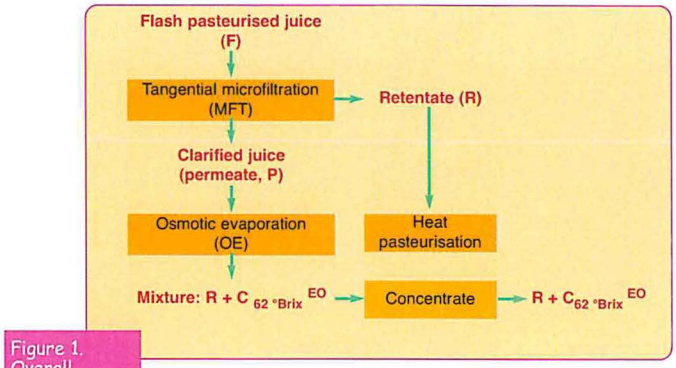

Figure 1. Overall process flow.

TMF retentate, previously pasteurised, is also considered to be equivalent to the initial juice (F) and distinctly better than the commercial orange juice produced by classic vacuum evaporation technology with recovery of the aroma (FCOJ). In contrast with classic concentrated juice, the colour is totally conserved, losses of aroma and nutritional compounds are very limited and the sugar:acid ratios are conserved (Table 1).

Table I. Main characteristics of the orange juices.

	F	PT	P	F R P C62°Brix	OE R+C62°Brix	OE FCOJ (65° Brix)
Viscosity (25°C, mPa.s)	1,1 (0,4)	1,7 (0,4)	1,2 (0,3)	28,2 (0,7)	1,6 (0,3)	37,3 (0,4)
Soluble solids (g SS.kg-1)	118 (2)	130 (2)	115 (2)	620 (2)	118 (2)	655 (2)
Solids in suspension (g.kg-1)	80 (3)	90 (4)	0	0	80 (2)	80[c] (2)
Titratable acidity (g citric acid.kg-1SS))	68 (1)	62 (2)	61 (1)	62 (1)	63 (1)	44 (1)
Glucose (g.kg-1 SS)	186 (1)	188 (2)	185 (2)	187 (2)	185 (2)	114 (1)
Fructose (g.kg-1 SS)	220 (2)	221 (2)	220 (2)	221 (2)	219 (2)	136 (1)
Sucrose (g.kg-1 SS)	491 (2)	494 (2)	489 (2)	491 (2)	48 (2)	291 (2)
Carotenoids (g.kg-1 SS)	0,38 (0,04)	0,34 (0,05)	> 0,02	> 0,02	0,35 (0,05)	0,24 (0,05)
Vitamin C (g.kg-1 SS)	3,7 (0,3)	3,3 (0,2)	3,6[a] 3,5[b] (0,3)	3,3 (0,3)	3,2 (0,3)	2,2 (0,2)
Colour L°	52	62	62	25 (61[d])	53	20 (28[c])
Hue angle (H°)	88	82,3	88,3	38,7 (88,3[d])	88	63,4 (86,4[d])
Saturation (C°)	30	37,3	17	25,6 (17[d])	29	31 (15[d])
Aromatic compounds (mg.kg-1 SS)						
Alcohol	2 405	397	2 141	1 808	1 946	1 649
Terpenic hydrocarbons	2 851	2 576	1 717	1 376	2 107	1 751
Aldehydes	112	43	102	81	93	46
Esters	1 810	291	1 795	1 216	1 363	544
Terpenols	166	152	135	119	137	102

Average of 6 analyses :
[a] After TMF; b Before OE; c After dilution to 118 g.kg-1 TSS; d After dilution to 115 g.kg-1 TSS.

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Département des productions fruitières et horticoles
Conception et réalisation : Cirad, Pôle Communication, département Flhor, February 2006

The volatile compounds giving the natural aroma of vanilla

A. Pérez-Silva[ad], E. Odoux[a], P. Brat[a], F. Ribeyre[a], G. Rodriguez-Jimenes[b], V. Robles-Olvera[b], M. A. García-Alvarado[b] and Z. Günatac*

[a] Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)TA 50/16, 34398 Montpellier Cedex 5, France

[b] Instituto Tecnológico de Veracruz, calzada Miguel Angel de Quevedo 2779, 91860 Veracruz, Veracruz, Mexico

[c] UMR Ingénierie des Réactions Biologiques et Bioproductions, Université de Montpellier II, place E. Bataillon, 34095 Montpellier Cedex 5, France

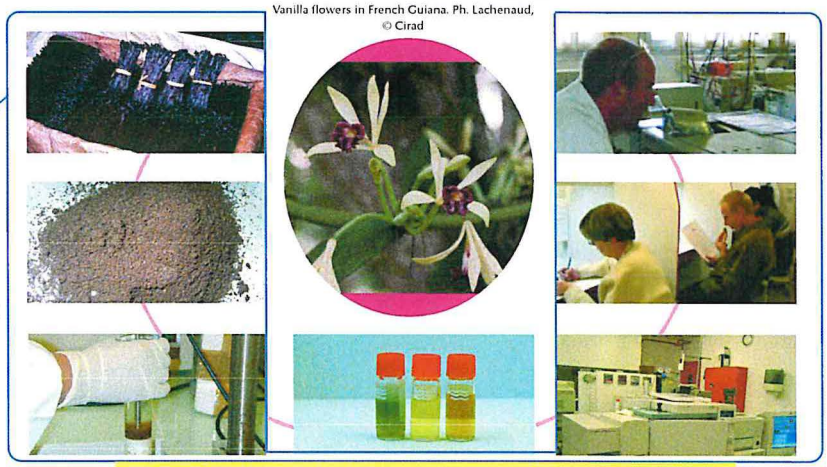
[d] Instituto Tecnológico de Tuxtepec, calzada Victor Bravo Ahuja s/n. 6380 Tuxtepec, Oaxaca, Mexico

odoux@cirad.fr

The aroma of vanilla develops during the transformation in which the green aroma-less fruit develops a highly aromatic black pod. We developed an extraction technique to obtain representative extracts of vanilla aroma in order to monitor the appearance of the components of the aroma.

Materials and methods

Extraction was performed on powdered vanilla using three organic solvents: ether (E), pentane/ether (P/E) and pentane/dichloromethane (P/D). The representativeness of each extract with regard to the natural aroma of vanilla was then evaluated by sensorial analysis. The aroma compounds in these different organic extracts were identified by mass spectrometry (GPC-MS) and quantified by gas phase chromatography (GPC-FID). Their respective olfactive intensities were then determined by GPC olfactometry (GPC-O).



Vanilla flowers in French Guiana. Ph. Lachenaud, © Cirad

Methodology for the analysis of the aroma compounds of vanilla

Results

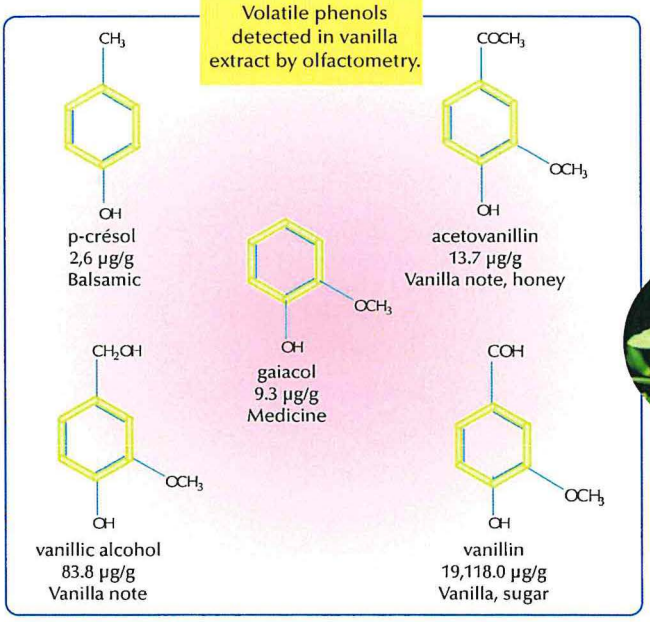
GPC-MS analysis showed that the P/E extract contained the largest number of aroma compounds (65); these were mainly acids (25), phenols (15) and alcohols (10). Furthermore, sensorial analysis of the aroma of the organic extracts showed that the P/E extract was not significantly different from natural vanilla aroma (powder), whereas significant differences were found with extracts E and P/D. The P/E extract was therefore chosen for the quantification of volatile compounds by GPC-FID and for olfactive characterisation by GPC-O.

The vanillin content of the extract chosen forms 85% of total aroma compounds. However, GPC-O enabled the identification of 25 other scent compounds. The olfactive intensities of substances such as gaiacol, 4-methylgaiacol and acetovanillin are similar to that of vanillin although the concentrations are 1000 times smaller. Other compounds such as methyl salicylate, p-cresol, methyl cinnamate and anisyl alcohol also display strong olfactive intensities although the concentrations are 10,000 times less than that of vanillin. All these compounds contribute soft, woody, balsamic, spicy, grilled and vanilla notes.

Aroma compounds identified by GPC-O in the pentane/ether extract of powdered vanilla.

Compound		Concentration (µg/g)	Descriptor	Intensity
Phenols	gaiacol	9.3	Medicine, sweet	+ ++
	4-methylgaiacol	3.8	Sweet, wood	+ ++
	p-cresol	2.6	Balsamic, spicy	+ +
	4-vinylgaiacol	1.2	Medicine	+
	4-vinylphenol	1.8	Sweet, wood	++
	vanillin	19,118.0	Vanilla, sweet	+ + +
	acetovanillin	13.7	Vanilla, sweet, honey	+ + +
	vanillic alcohol	83.8	Vanilla note	+ + +
	p-hydroxybenzaldehyde	873.3	Vanilla note, cake	++
	p-hydroxybenzylic alcohol	65.1	Vanilla note, sweet	+ +
Aliphatic acids	acetic acid 1	24.3	Vinegar	+ +
	isobutyric acid	1.7	Butter	+ +
	butyric acid	<1	Butter, oily	+
	isovaleric acid	3.8	Butter, oily	+ +
	valeric acid	1.5	Cheese	+ ++
2,3-butanediol alcohols (isomer 2)		8.0	Floral	+
	anisyl alcohol	2.4	Herbal	+ +
Aldehydes	2-heptenal	2.1	Green, oil	+
	(E)-2-decenal	1,8	Green, floral	+ +
	(E, Z)-2,4-decadienal	1.4	Green, fresh	+ +
	(E, E)-2,4-decadienal	1.2	Oil	++
Esters	methyl salicylate	<1	Chalk	+++
	methyl cinnamate	1.1	Sweet, fruit	++
	ethyl linolenate	13.5	Grilled, sweet	+ +
Ketone	3-hydroxy-2-butanone	14.6	Butter, mushroom	+
Unknown		6.2	Vanilla note, chemical	+++

Volatile phenols detected in vanilla extract by olfactometry.



Conclusion

GPC-O analysis of a representative extract of vanilla aroma showed that in addition to vanillin, volatile phenols (e.g. gaiacol and p-cresol)are of capital importance in the natural aroma of vanilla, even at very small concentrations.

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Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, novembre 2005

Leafy vegetables in the tropics: high nutritional and economic values as arguments to preserve their diversity and to invest in knowledge

R. KAHANE, L. TEMPLE[1], P. BRAT[2], H. DE BON
CIRAD département Flhor, Boulevard de la Lironde, 34398 Montpellier cedex 5
[1]Unité Propre de Recherche « Horticultures »,
[2] Unité Propre de Recherche « Qualité des aliments tropicaux »
pierre.brat@cirad.fr

Research and investment efforts are concentrated on a limited number of marketable species, including the most "sophisticated" vegetables from developed countries (F1 hybrids). The indigenous leafy vegetables remain, however, highly cropped and consumed in the tropics. Their natural diversity and the various sources of supply allow them to be present on the markets the all year round. They are bought fresh, regularly, meaning either they are cropped not too far from the market, or using efficient logistics. Leafy vegetables often lack of organization in their commodity chain, from the production to the marketing, and suffer from the competition with "modern" vegetables, revealing conflicts between ancient and new generations. The food transition habits of urban citizens, who consume more and more animal proteins and imported cereals, often carries diet deficiencies in vitamins, due to less fresh fruits and vegetables. Tropical leafy vegetables contain 10 to 100 fold the micro-nutrient content of lettuce, cabbage or leek. Such an argument favouring public health should be considered to restore economic and scientific interest in leafy vegetables.

Amaranthus retroflexus L. green (Ciba-Geigy, 1976)

The diversity in leafy vegetables in the tropics

The vegetables in Asia and Africa count about 884 and 1025 domesticated or wild species, respectively. Amongst the 275 vegetable species the most important in tropical Africa, 207 are consumed for their leaves, and 31 in addition are known and used for various other purposes, like root and tuber crops, or trees, from which leaves represent an substantial nutritional value (PROSEA, 1993; PROTA, 2004) .

Nutritional value of tropical leafy vegetables

Traditional vegetables (or indigenous, in contrast to exotic vegetables in the temperate countries) are generally richer in minerals, vitamins and nutritional factors. Concentrations in iron, vitamins A and C (Table 1) are linked to health value, particularly in the countries hosting malaria and other severe immunity deficiencies.

Table 1. Concentrations of iron and vitamins A and C in some fresh leafy vegetables (from Bailey, 2003)

vegetables	Iron concentration (in µg/100 g FW)	Pro-Vit. A (in µg equivalent Retinol/100 g FW)	Concentration in Vit. C (in mg/100 g FW)
Lettuce	1,1-1,5	151-304	13-28
Cabbage	0,5-0,6	18	38-40
Pakchoy	1,1	186	35
Kangkong	3,1	793	49
Amaranth	8,7	953	66
Cabbage kanak	9,3	661	19
Nightshade	19,0	285	26
Taro (leaves)	2,7	744	90

The tropical leafy vegetables are most of the time strongly coloured, due to high concentrations in carotenoïds that carry healthful anti-oxidative properties. Amongst these carotenoïds, precursors of vitamin A (ex. ,-carotene) and lutein, prevent from severe diseases like macular degenerating and cataract, various cancers and heart attack. The most colourful vegetables are advisable, and the darkest varieties compared to the lightest (Table 2).

Table 2. Concentration of ,-carotene and lutein in dry leafy vegetables compared to their colour (mean ± standard error, N=4)

Leafy vegetables	Dry matter content (in % FW)	Concentration (in µg/g DW) of ß-carotène	Lutéine
Kangkong	7,8 ± 0,2	1159 ± 41	216 ± 19
Roselle	10,1 ± 0,6	1198 ± 53	231 ± 19
Amaranth dark green	9,6 ± 0,2	1017 ± 37	190 ± 30
Amaranth green	8,8 + 0,2	920 ± 22	172 ± 14
Amaranth light green	8,5 ± 0,6	462 ± 21	69 ± 7
Amaranth red	8,5 ± 0,2	1445 ± 54	287 ± 18

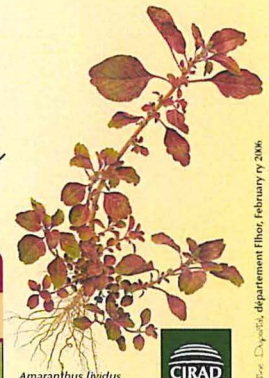
The leafy vegetables are rarely single dish, but consumed as sauce or together with staple food. Such a combination has social and economic significances, and also nutritional ones: it often improves the bio-availability of the micronutrients contented in the vegetables, either through the combination of ingredients (presence of lipids especially), or due to the food preparation.

Characterizing the effect of food processing on the nutritional value of leafy vegetables

Characterizing the nutritional value of leafy vegetables is a huge task, already investigated (AVRDC in Taiwan, NRI in the UK, University of the Virgin Islands in USA). CIRAD decided to focus on the analytical protocols, to standardize the methods (including sampling), to estimate the bio-availability of micronutriments and vitamins in leafy vegetables, and to evaluate the effect of food processing on their nutritional value: content and bio-availability of micronutrients (Table 3). The methods still need to be addressed, due to undesired extraction micronutrient during the process and new combinations of chemical compounds.

Table 3. Total content in carotenoids and in vitro bio-availability before and after standardized cooking of leafy vegetables

	Before cooking		After cooking	
	b-carotene	Lutein	b-carotene	Lutein
Content (in mg/100 g DW)				
Kangkong	110 ± 28	22 ± 13	118 ± 37	20 ± 6
Amaranth green	57 ± 18	14 ± 7	70 ± 5	16 ± 1
Amaranth red	88 ± 9	18 ± 4	117 ± 19	21 ± 4
Bio-availability (in mg/100 g DW)				
Kangkong	0	0,30 ± 0,05	0	0,10 ± 0,07
Amaranth green	1,0 ± 0,3	0,07 ± 0,05	2,0 ± 1,0	1,0 ± 0,5
Amaranth red	2,0 ± 0,3	1,60 ± 0,30	2,0 ± 0,5	2,0 ± 0,6



Amaranthus lividus L. red (Ciba-Geigy, 1976)

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Département des productions fruitières et horticoles
www.cirad.fr

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Risk assessment and management

Integrated protection of tomato against begomovirus diseases

Begomoviruses are phytoviruses spread by the whitefly Bemisia tabaci *and are a serious threat to vegetable crops around the world, especially in the tropics [1]. These micro-viruses affect tomato crops in particular in Guadeloupe and Martinique. Management of these diseases is currently based on intensive chemical control and cultural practices suited to large-scale production. This is not suitable for the West Indian context of small open fields. Integrated protection based on understanding of epidemics could make it possible to identify strategies suited to the socio-agronomic context.*

Adulte du vecteur *B. tabaci*.

C. Urbino[1], M.L. Caruana[2], C. Pavis[1], D. La Fortune[1] N. Boissot[1] J. Dintinger[3]

1. Cirad-Inra, Domaine Duclos, 97170 Petit Bourg, Guadeloupe, France
2. Cirad, UMR/BGPI, TA 41 / K, campus de Baillarguet, 34398 Montpellier Cedex 5, France
3. Cirad, UMR PVBMT, Station de Ligne-Paradis - Pôle 3P, 7 chemin de l'Irat, 97410 Saint-Pierre, Réunion, France
urbino@cirad.fr

Symptoms of TYLCV begomovirus in tomato

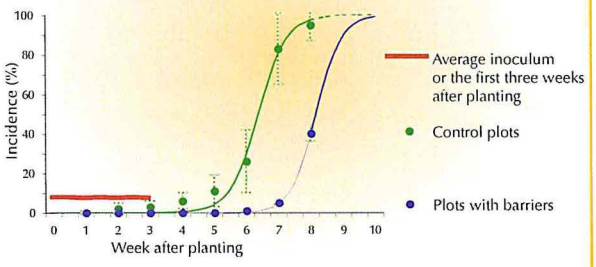
Methods

- Characterisation of the vector B. tabaci and of begomoviruses.
- Search for sources of resistance to several begomoviruses.
- Identification of the risk zones and key factors that favour begomovirus epidemics.
- Setting up experiments to evaluate the advantages of cultural practices.

Results

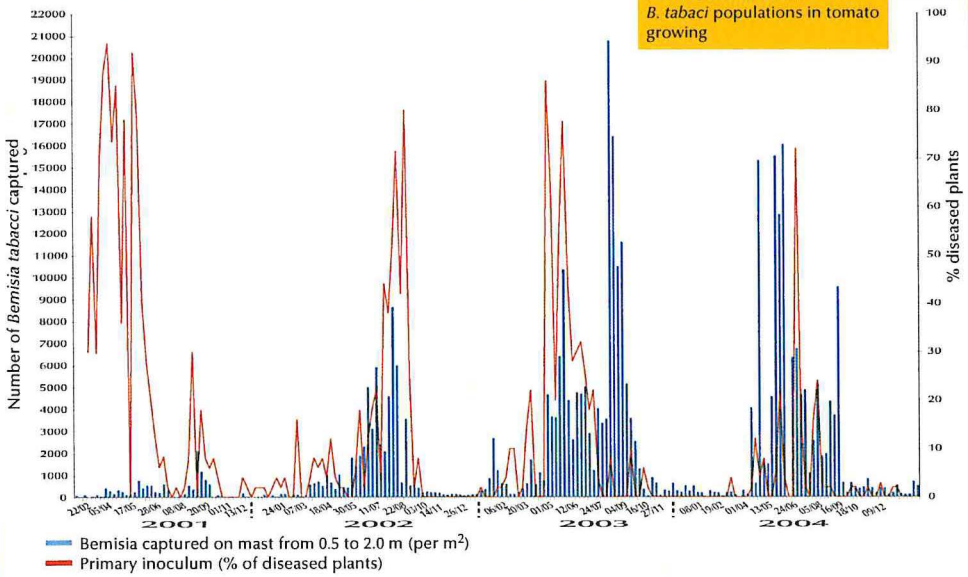
- Two begomoviruses, PYMV and TYLCV, whose damage is known world-wide [2] seriously affect tomato production in the French West Indies. Most of the B. tabaci populations are biotype B which is polyphagous and extremely effective in spreading begomoviruses.
- A source of resistance to PYMV has been identified and analysis of this resistance is in progress.
- Surveys showed that all the vegetable production zones in Guadeloupe and Martinique are concerned.
- The diversity of cultural practices is great and some enhance the occurrence of epidemics. Growing tomato all the year round favours the maintaining of the main sources of inoculum, as well as the contamination of nurseries and young field crops adjoining old, contaminated fields.

The use of physical barriers likely to slow the development of epidemics has given promising results but only during periods of low inoculum levels. A guard space making it possible to reduce inoculum sources at the end of the vegetable season, combined with physical protection, could slow the contamination of fields during the early weeks after planting.



Delaying the spread of begomoviruses in the presence of physical barriers

Monitoring primary inocula and the evolution of *B. tabaci* populations in tomato growing



The study of the population dynamics of *B. tabaci* and of the level of primary begomovirus inocula showed that the latter are present all the year round although the level is higher from June to September. The incidence of the disease was found to be greater when the inoculum level had been high in the first three weeks of cultivation.

Prospects

This work could be continued by the development of models of epidemics at field scale followed by adjustment with data drawn from experiments. Other integrated protection scenarios matching the socio-agronomic contexts could then be tested.

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2 Moriones E., Navas Castillo J. (2000). Tomato yellow leaf curl virus, an emerging virus complex causing epidemics worldwide. Virus Res., 71 (1/2) : 123-134.

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Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, avril 2005

Mosquito net for crops may reduce the insecticide pollution in peri-urban areas of Africa

Th. Martin[1], F. Assogba-Komlan[2], Th. Houndete[2], J.-M. Hougard[3], F. Chandre[3]
[1] IRD-Cirad-Crec, 01 BP 4414, Cotonou, Benin, thibaud.martin@cirad.fr
[2] Inrab, 01 BP 884, Cotonou, Benin
[3] IRD-Crec, 01 BP 4414 Cotonou, Benin
thibaud.martin@cirad.fr

Cabbage field trial comparing an insecticide foliar protection, a netting protection and an unprotected control.

To reduce the insecticide contamination of environment, which is strongly suspected to select insecticide resistance in mosquitoes from peri-urban areas, we experienced to replace foliar sprays on vegetables by using mosquito netting. The protection of cabbages using a net was investigated in a field trial in Benin during the dry season.

Methods

A trial was implemented in November in the Research Centre of Agonkanmey (Benin). Four treatments were compared in a Fisher block design:

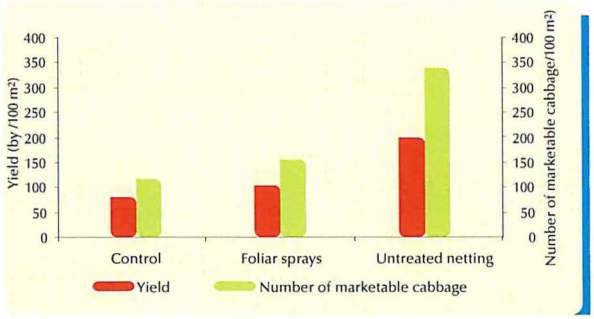
- insecticide treated net (only for seedling nursery),
- untreated net,
- local insecticide protection with 10 sprays of deltamethrin at 12 g/ha,
- a control without any protection.

Nets, from local market, were in knitted polyester with 25 holes/cm^2. Treated nets were impregnated two days before use by dipping with deltamethrin at 50 mg/m^2. Four wood pickets were placed at each corner to maintained nets at 50 cm height in the seedling nurseries. The nets were removed during the day when the flight activities of pests were reduced to suppress the problem of overheating and excessive shade.

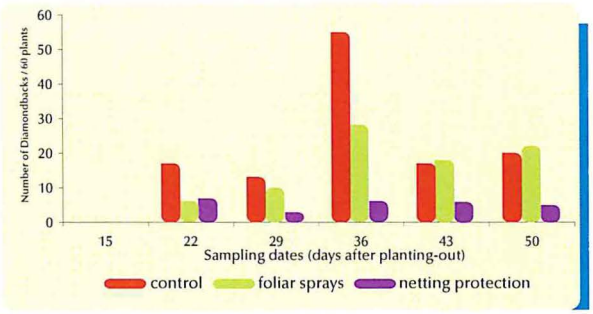
Cabbage plots at harvest time. The left plot was protected with an untreated net. The right plot was not protected.

Results

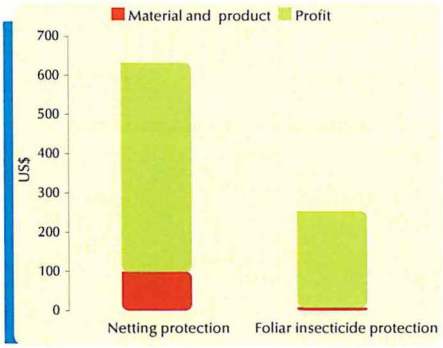
Nets were very effective to protect cabbages from caterpillar attacks, particularly the Diamondback moth *Plutella xylostella*. An insecticide treated net allowed a better protection against small pest such as aphids when compared with an untreated net. At harvest time, the production of marketable cabbages with a netting protection was significantly better than a foliar insecticide protection. Netting protection is an economical and valuable method for cabbage protection .



Number of marketable cabbages and yield at harvest time.



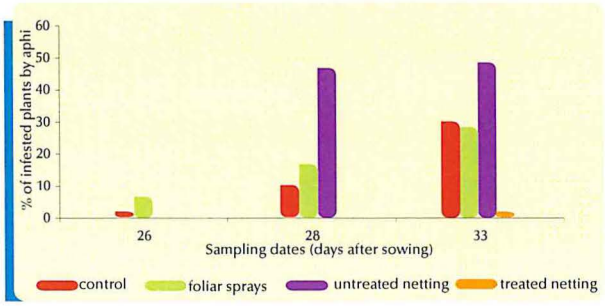
Evolution of Diamondback moths per cabbages.



Cabbage crop profit per 100 m^2.

Conclusion

A mosquito net may efficiently protect vegetables against a wide range of pests. Netting protection could prevent unsustainable insecticide practices in peri-urban areas of tropical countries. The material is available on local market and can be cost effective as it could be easily used many times. This technique could benefit from the large scale implementation of bednets in Africa by the national malaria programmes and conversely.



Percentage of infested plants by aphids in seedling nurseries.

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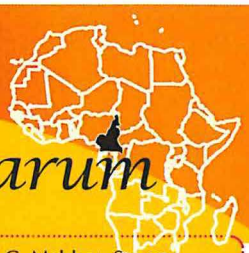
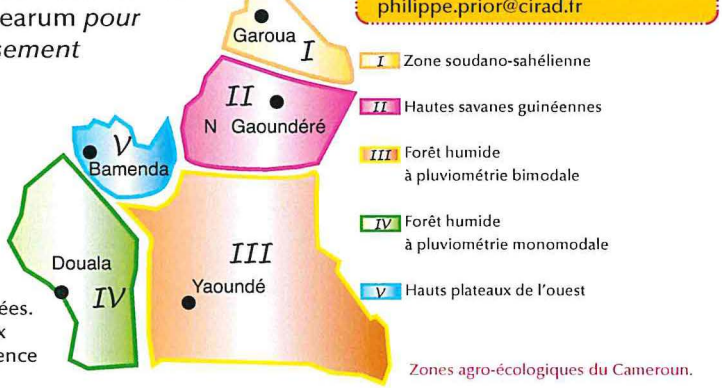
Diversité génétique des souches camerounaises de Ralstonia solanacearum



G. Mahbou Somo Toukam[1], C. Guilbaud[2], Ph. Prior[2, 3]
[1] Irad, Programme Légumineuses et cultures maraîchères, Yaoundé, Cameroun
[2] Inra, Laboratoire de Phytobactériologie, UR407, Avignon, France
[3] Cirad, Pôle 3P, UMR PVBMT, St-Pierre cedex, La Réunion, France
philippe.prior@cirad.fr

Les missions de développement agronomique confiées aux principaux instituts camerounais de recherche pour le développement agricole (IRAD, CARBAP, IITA) portent un intérêt particulier à la reconnaissance du flétrissement bactérien provoqué par Ralstonia solanacearum *et à son contrôle. Compte tenu des pertes considérables provoquées par cette bactériose et de la forte diversité génétique et phénotypique décrite dans ce complexe d'espèce, il convenait de décrire les souches présentes au Cameroun. Ces travaux pionniers servent les connaissances des souches africaines de* R. solanacearum *pour l'orientation des stratégies de lutte contre le flétrissement bactérien.*

Maraîchers cultivant des bas fonds en zone d'altitude.



Zones agro-écologiques du Cameroun.

Matériel et méthodes

Seules les zones agro-écologiques 2, 3, 4 et 5 ont été prospectées : 3000 kms, 52 sites, 200 échantillons prélevés sur des plants flétris ou non, 7 espèces hôtes différentes (tomate, piment, poivron, pomme de terre, morelle noire, amarante, pastèque), pour 104 souches collectionnées. La diversité génétique a été décrite en référence à la classification et aux outils moléculaires proposés par Fegan et Prior et par l'analyse de séquence du gène *mutS* [1]. Les souches tombant dans le phylotype II ont été éprouvées par Multiplex-PCR 'Musa' et par le couple d'amorces 630/631, pour le diagnostic respectif de souches 'Musa' (MLG24, 25 ou 28) ou 'Brown rot' (souches PdT dites 'froides').

Symptômes caractéristiques de flétrissement sur la tomate : épinastie foliaire et affaissement brutal de la plante.

Symptômes atypiques de flétrissement sur amarante où le brunissement des nervures traduit la vascularisation.

Flétrissement sur poivron.

Flétrissement sur morelle noire.

Résultats

Les phylotypes I (asiatique), II (américain) et III (africain) sont présents au Cameroun. Aucune souche de phylotype IV (indonésien) n'a été repérée. La distribution géographique des différents phylotypes indique que le phylotype III est présent dans les zones agro-écologiques 3, 4 et 5 : il s'agit donc de souches d'altitude et de plaine. Les souches tombant dans le phylotype I sont majoritairement présentes dans la région de Yaoundé. Le phylotype II camerounais a une large distribution et héberge des souches Solanées et PdT. Aucune souche de type 'Moko' (MLG24, 25 ou 28) n'a été détectée dans cette étude.

Diversité génétique des souches camerounaises de *Ralstonia solanacearum* basée sur le polymorphisme de séquence du gène *mutS* et PCR-multiplexes.

Zone agro-écologique	Phylotype I	Phylotype II		Phylotype III
		Solanées	PdT (a)	
II	–	1	–	–
III	47	20	–	2
IV	1	–	–	5
V	1	9	5	13
104 souches	49 (47 %)	30 (29 %)	5 (5 %)	20 (19 %)

(a) Souches pathogènes de la pomme de terre, encore dite "souches froides" ou agent du 'Brown rot' (CMR18, CMR24, CMR34, CMR35, CMR44). Les 104 souches de R. solanacearum isolées au Cameroun

Référence

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Perspectives

Une étude phylogénétique basée sur l'analyse de séquences du gènes *egl* (endoglucanase) est en cours pour positionner ces souches originales dans les deux arbres phylogénétiques de référence [1]. L'ensemble de ces travaux sur la structuration de la bio-diversité de *R. solanacearum* au Cameroun permettront d'optimiser la gestion du risque lors de l'introduction de matériel végétal (vivrière, maraîchages) et sont indispensables à tout programme d'amélioration des plantes pour la résistance au flétrissement en Afrique.

Maraîchers progressant en forêt secondaire.

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Conception et réalisation : Cirad, département Flhor, avril 2005

Natural contamination of citrus orchards by greening disease with several chemical control procedures for the psyllid vector *Diaphorina citri*

Frédéric Gatineau
Cirad, Southern Fruit Research Institute (SOFRI), PO Box 203, My Tho, Tien Giang, Vietnam
gatineau@cirad.fr

Figure 1. The psyllid *Diaphorina citri*, the vector of *C. Liberibacter asiaticus*.

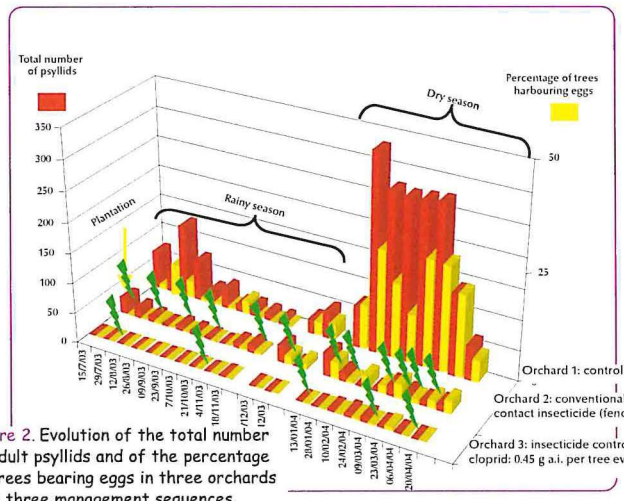
Greening is a severe disease of citrus and one of the major threats to citrus growing. The etiological agent in Asia is the alpha-proteobacterium Candidatus *Liberibacter asiaticus. This phloem bacterium is spread under natural conditions by the psyllid* Diaphorina citri, *a phloem-feeder associated with plants of the Rutaceae family (Figure 1). Control of the psyllid vector populations is currently the only strategy for preventing the spread of the disease and the contamination of young orchards. Two insecticide control procedures were evaluated in southern Vietnam.*

Impact of the control procedure on *D. citri* population dynamics

• Without spraying (orchard 1, Figure 2), the D. citri population increases substantially during the dry season (from January to May). The increase is the result of strong migration to different fields and the multiplication of the psyllid within fields (strong oviposition). Insect pressure is at its maximum in this season. The population and oviposition decrease substantially during the rainy season (June to December).

• Contact insecticide (orchard 2) destroys the population of the plot at each spraying and prevents outbreaks of the insect during the dry season. However, the low persistence of the substance does not prevent rapid recolonising of the orchard (5 to 7 days after spraying) by psyllids from nearby orchards; these insects initiate a multiplication cycle in the orchard.

• Systemic insecticide with high persistence (orchard 3) enables better control of the recolonising of the field and strongly reduces oviposition in the orchard.



Orchard 1: control orchard with no insecticide sprayed.

Orchard 2: conventional insecticide treatment: spraying at 15-day to monthly intervals with a contact insecticide (fenobucarb at 250 g a.i. per ha).

Orchard 3: insecticide control: application to the trunk or by watering with a systemic insecticide (imidacloprid: 0.45 g a.i. per tree every 3 months or 0.15 g a.i. per tree every month).

Figure 2. Evolution of the total number of adult psyllids and of the percentage of trees bearing eggs in three orchards with three management sequences.
↯ : insecticide treatment

Impact of the management sequence on orchard infection dynamics

The trees in the three orchards were sampled and tested for the detection of *C. Liberibacter asiaticus* five months after planting, that is to say at the end of the rainy season (Figure 2).

• *C. Liberibacter* asiaticus was detected in 2.13% and 2.90% of the trees respectively in the control orchard and in the orchard subjected to conventional insecticide spraying (Table 1). Detection gave negative results in all the trees in the orchard subjected to systemic insecticide control.

• Although conventional insecticide control limits *D. citri* populations, this procedure does not appear to be effective in controlling the contamination of orchards by greening disease because of the low persistence of the substance used. The systemic insecticide seems to have provided better protection of the orchard from both *D. citri* and the disease.

Table 1. Cumulated number of adult D. citri and the percentage of trees infected by greening 5 months after planting with application of the three technical procedures.

	Orchard 1 Témoin	Orchard 2 Conventiona insecticide	Orchard 3 Systemic insecticide
Cumulated number of psyllids on the date of the test	391	97	3
Infection at planting (%)	0	0	0
Infection 5 months after planting (%)	2,13	2,90	0

Conclusion

Even during the period of small to moderate pressure by *D. citri* (rainy season), the risk of contamination of the orchards by the disease remains high. The harmfulness threshold of the insect is thus very low. For this reason, in chemical control of psyllids and greening, technical procedures using systemic insecticides with high persistence (that are respectful of beneficial fauna) should be preferred to procedures using low-persistence contact insecticides (that are very harmful for beneficials) that require more frequent application and do not provide effective protection against greening.

CIRAD
Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, avril 2004

Humidity and host-plant as important factors influencing the pre-imaginal development of fruit flies (Diptera: Tephritidae)

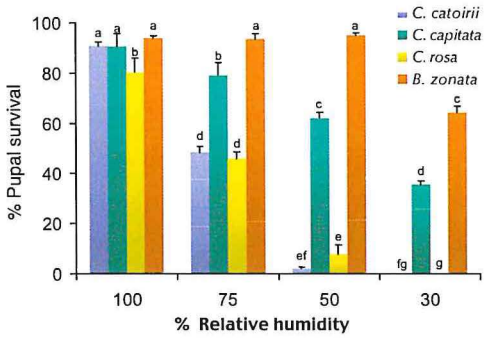
Pierre-François DUYCK[1], Patrice DAVID[2], Serge GLENAC[1] & Serge QUILICI[1]

[1] CIRAD Pôle de Protection des Plantes, Réunion, France; [2] CNRS Centre d'écologie Fonctionnelle et Evolutive, Montpellier, France

Fruit flies (Diptera: Tephritidae) are serious pests on fruit and vegetable crops in most tropical countries. In Reunion Island, four species of Tephritidae cause damages on fruit crops namely the Mascarenes fruit fly, *Ceratitis catoirii* (Guérin Mèneville), the Mediterranean fruit fly, *C. capitata* (Wiedemann), the Natal fruit fly, *C. rosa* Karsch, and the recently invasive peach fruit fly, *Bactrocera zonata* (Saunders).
If temperature has a strong influence on the survivorship during the pre-imaginal development of these four species (Duyck and Quilici 2002; Duyck *et al.* 2004), the influence of humidity and host fruit has received little attention up to now.

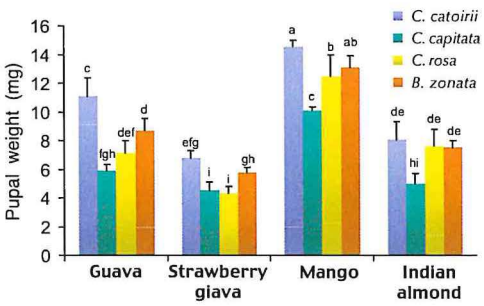
Influence of humidity

A range of relative humidity (100, 75, 50 and 30% RH) has been obtained by placing a solution of water alone or a solution of water saturated with NaCl, $Mg(NO_3)_2.6H_2O$ or $MgCl_2.6H_2O$ in an hermetic box, respectively (Winston and Bates 1960).



2-way ANOVA and Student Newman-Keuls multiple range test on Arcsin (Sqrt[X]), $P < 0.05$

Influence of host fruit

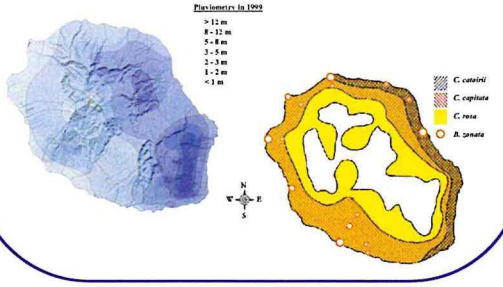


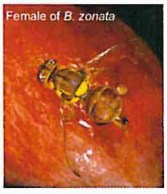
Parameter	Fruit fly species	Fruit species			
		Guava	Strawberry guava	Mango	Indian almond
% Survival to pupation	*B. zonata*	73 ^{bcd}	74 ^{bcd}	73 ^{bcd}	95 ^{a}
	C. capitata	58 ^{cd}	50 ^{d}	64 ^{cd}	79 ^{bc}
	C. rosa	90 ^{ab}	49 ^{d}	64 ^{cd}	82 ^{bc}
	C. catoirii	73 ^{bcd}	22 ^{e}	67 ^{cd}	74 ^{bcd}
Larval development time (days)	*B. zonata*	9 ^{fg}	14 ^{c}	7 ^{g}	10 ^{ef}
	C. capitata	12 ^{cde}	16 ^{b}	9 ^{fg}	13 ^{cd}
	C. rosa	12 ^{cd}	16 ^{b}	12 ^{cd}	12 ^{ef}
	C. catoirii	13 ^{cd}	18 ^{a}	9 ^{fg}	13 ^{cd}

2-way ANOVA and Student Newman-Keuls multiple range test on untransformed data for developmental times, on Arcsin (Sqrt[X]) for survival and on Sqrt [X] for pupal weight, $P<0.05$

According to the different parameters, mango appears to be a good larval host for the four fruit flies species. *Bactrocera zonata* developed very well in the four fruit species notably on strawberry guava although this fruit, which is widespread in the island, is not a common host for this species. Preferences of females should be studied to confirm the potential importance of this wild host in the multiplication of *B. zonata*.

- *Ceratitis capitata* and particularly *Bactrocera zonata* showed a high tolerance to dryness contrary to *C. catoirii* and *C. rosa*.
- Our results are in accordance with the observed distribution of *Ceratitis catoirii* which is mostly present on the wet windward coast of Reunion island. *Ceratitis rosa* is present in most areas of Reunion island up to an altitude of 1500 m but is more prevalent on the east coast and in altitude where humidity is high.





Conclusions

- Host-fruit species influences survivorship and developmental time of larvae and also strongly influences pupal weight. The relationship between host-fruit species, pupal weight and fecundity of the emerging females will require further studies.
- Humidity strongly influences the distribution of fruit flies in Reunion island. Similarly the potential distribution in the Mediterranean area of *Bactrocera zonata* which is currently invasive in Egypt will probably be affected by this factor.

➡ These two factors could be used in addition to temperature thresholds as important tools for pest risk analysis (PRA).

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Pierre-François Duyck
CIRAD Pôle de Protection des Plantes (3P),
UMR, Peuplements végétaux et bio-agresseurs en milieu tropical,
7 chemin de l'IRAT,
97410 Saint-Pierre
Ile de la Réunion (France)
E-mail : duyck@cirad.fr

REGION REUNION CONSEIL REGIONAL
CENTRE D'ECOLOGIE FONCTIONNELLE & EVOLUTIVE
CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
CIRAD Centre for international cooperation in agricultural research for development

RISK ASSESSMENT OF SPREADING *BANANA STREAK VIRUS* (BSV) THROUGH *IN VITRO* CULTURE

M. Folliot [1], S. Galzi [1], N. Laboureau [1], M.-L Caruana [2], P.-Y. Teycheney [3], & F.-X. Côte [1]

[1] CIRAD, TA50/PS4, Boulevard de la Lironde, F-34398 Montpellier cedex 5, France - francois.cote@cirad.fr
[2] CIRAD-UMR BGPI, TA 41/K, Campus International de Baillarguet, F-34398 Montpellier cedex 5, France
[3] CIRAD-UPR75, Station de Neufchâteau, Sainte- Marie, F-97130 Capesterre Belle Eau, Guadeloupe, FWI

Centre de coopération Internationale en Recherche Agronomique pour le Développement

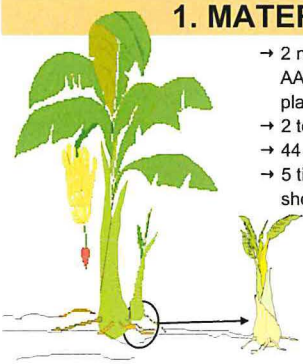
BACKGROUND

***In vitro* multiplication** is one of the main **abiotic stresses** triggering the production of episomal infectious particles of *Banana streak virus* (BSV) in inter-specific banana hybrids, through the activation of BSV **endogenous pararetrovirus** (EPRV) sequences integrated into the genome of *Musa balbisiana* (noted B). Nevertheless, mass production of vitroplantlets remains the most widely used method for diffusing wild *Musa* cultivars or new improved hybrid species. Therefore, there is a need to evaluate the effects of *in vitro* culture on the activation of BSV EPRVs and to **assess the risk of spreading BSV through the diffusion of micropropagated banana vitroplants**. Our work aims at:

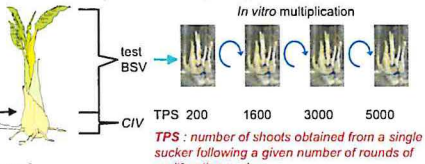
Identifying which steps of *in vitro* culture are involved in the activation of BSV EPRVs, for natural and created banana interspecific hybrid cultivars,

1. Checking whether all the hybrid cultivars studied here go through similar activation patterns during *in vitro* culture,
2. Checking whether distinct BSV EPRVs corresponding to distinct BSV episomal strains display similar activation patterns,
3. Checking whether distinct genotypes of banana hybrid cultivars behave differently during *in vitro* culture.

1. MATERIAL



→ 2 natural (**Kelong Mekintu & Penkelon**, genotype AAB) et 1 hybrid (**CRBP39**, genotype AAAB), plantain cultivars, all **healthy** (not infected by BSV)
→ 2 to 3 lines propagated *in vitro* for each cv,
→ 44 shoots analyzed at each time point,
→ 5 time points corresponding to TPS (total produced shoots) values of 0, 200, 1600, 3000 and 5000.



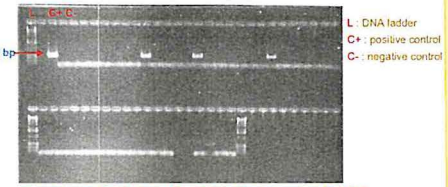
***TPS** : number of shoots obtained from a single sucker following a given number of rounds of proliferation cycles.*

Healthy mother plant and sucker

In vitro multiplication of plant material was performed by VITROPIC., a subsidiary of CIRAD specialized in mass propagation and commercialisation of banana and pineapple vitroplants.
Vitropic SA, ZAE des Avants, F-34270 St Mathieu de Tréviers, France - http://www.vitropic.fr/

2. METHODS

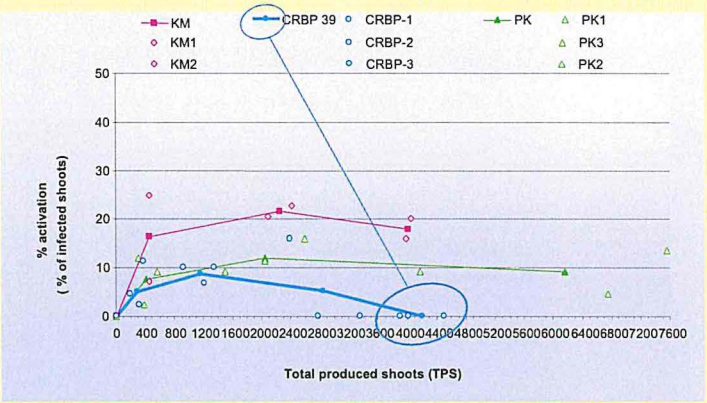
→ Detection of BSV strains Obino l'Ewaï (BSV-OI) and Goldfinger (BSV-Gf) by immunocapture PCR.



Detection of BSV-OI by IC-PCR in Penkelon line N°3317

3. RESULTS

% of plantlets infected by BSV-OI following increasing numbers of proliferation stages

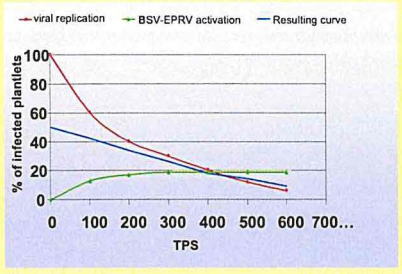


1. **The percentage of infected plantlets increases steadily at the beginning of the *in vitro* proliferation stage.**
2. **A percentage of infected plants comprised between 10% (Penkelon and CRBP 39) and 20% (Kelong Mekintu) is reached for TPS values comprised between 800 and 2000, depending on lines and cultivars. This percentage reaches a plateau then decreases. For hybrid CRBP39, 0% activation is reached at TPS = 2200.**
3. **There are differences in activation patterns depending on BSV strains. No BSV-Gf strain could be detected in the KM nor PK cultivars, although the *M. balbisiana* genome harbours activatable BSV-Gf EPRVs.**
4. **Shapes of the activation curves are similar for the three cultivars studied. Only TPS values registered at given times differ between cultivars.**

CONCLUSIONS & PROSPECTS

The pattern of infected plants observed during *in vitro* culture is the same for all the cultivars and BSV strains studied. It could result from concomitant **viral replication** and **BSV EPRV activation**.

Theoritical pattern of infected plants observed during *in vitro* culture



1. BSV-EPRV activation by *in vitro* culture.
2. **Viral replication**, with a dilution effect resulting from cellular multiplication being faster than viral replication during *in vitro* culture.
3. Addition of both phenomena could result in BSV-free plantlets being regenerated despite the presence and activation of BSV-EPRVs.

Have healthy (BSV-) vitroplants obtained at high TPS values lost their ability to express pathogenic BSV EPRVs?

Further experiments are in progress to check whether BSV- vitroplants obtained at high TPS values retain their healthy status. These experiments aim at unraveling EPRVs activation processes during *in vitro* culture, in order to mass produce safe banana germplasm by micropropagation

Does the activatable state of BSV EPRVs persist in healthy plantlets obtained at high TPS values?

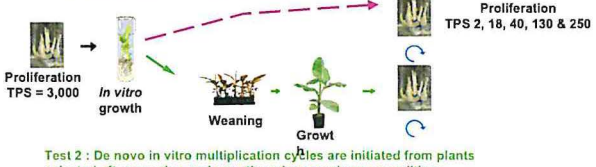
What is the level of transmission of BSV to the progeny from infected shoots following *in vitro* mass propagation?

Testing EPRV BSV reactivation by *in vitro* culture

(on 15 shoots from CRBP39 line 4791, certified BSV- at TPS = 2800)

This test aims at checking whether certified BSV- vitroplants obtained at high TPS values can give rise to BSV episomal particles when used as starting material for further *in vitro* mass propagation.

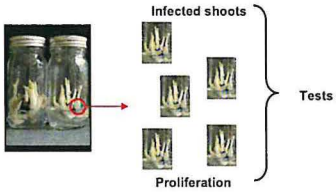
Test 1 : De novo *in vitro* multiplication cycles are initiated from vitroplants selected at the end of their growing phase (*in vitro*)



Test 2 : De novo in vitro multiplication cycles are initiated from plants selected after weaning and growth under greenhouse conditions

Testing the virus dilution hypothesis

BSV- OI infected CRBP39 shoots are used as starting material for de novo in vitro mass propagation.



European regulatory constraints on pesticide use for tropical products exported to the European Union

CIRAD assistance to export chains

H. VANNIERE
CIRAD département Flhor,
Boulevard de la Lironde,
34398 Montpellier cedex 5
henri.vanniere@cirad.fr

SINCE 1991, the European Union has attempted to harmonise pesticide use regulations between its member states. Diagram 1 shows the different scenarios faced by producers and exporters from countries of the African-Caribbean-Pacific zone (ACP).

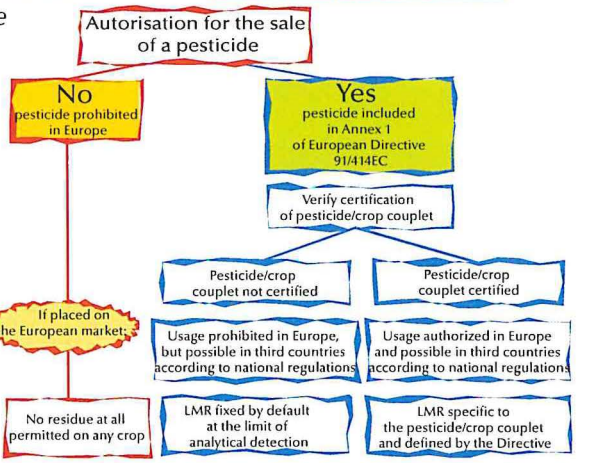


Diagram of pesticides certification – definition of LMRs

Objectives

The Pesticides Initiative Programme (PIP), implemented by the Europe/Africa-Caribbean-Pacific Liaison Committee (COLEACP), was created by the European Union at the request of the ACP countries. It was assigned two objectives:

- to enable companies exporting horticultural products to conform to European standards concerning sanitary quality and traceability;
- to strengthen the place of small producers within horticultural export chains.

Cirad has participated in this programme in five West African countries on three export chains: pineapple and papaya (Ivory Coast and Ghana), and mango (Guinea, Mali and Senegal).

Approach

The experience gained by Cirad teams has permitted an integrated approach to be proposed that incorporates technical assistance, research and training. Our aid to companies is not limited to technical assistance alone. It proceeds through five phases, which we illustrate by the case of mango.

The pesticide salesman also plays the role of adviser

Preliminary bibliographical studies and initial contacts with companies

- Characterisation of the export chain; expectations of product quality
- Description of food safety context: potential dangers, risk perception by the producers
- Description of regulatory context

Inventory and initial recommendations

- In situ evaluation of food safety risks
- Description of practices and identification of pesticides used
- Characterization of the technical and scientific environment:
  - Routes for the recommendation and distribution of pesticides
  - Presence and reliability of analytical laboratories
  - Information and experimental centres
- Immediate recommendations

Analysis of initial results and definition of supplementary needs

- Prioritisation of identified needs
- Identification of additional research needed on pests and pathogens with a significant impact on production
- Identification of additional studies needed on pesticides within a given production zone: trials of efficacy and on residues
- Identification of training needs for technical personnel from companies and extension services

Black spots, symptoms traditionally associated with anthracnose

pathogens identified: Stemphyllium, Dothiorella, Cercospora, Alternaria, Cladosporium sp.

RESIDUES TRIALS

insecticides to control fruit fly on mango in Mali

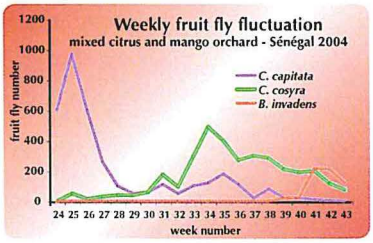
(GAP : number of treatment = 2, interval between application = 10 days)

active ingredient		Spinosad	Deltamethrine	Malathion	Imidaclopride	Bifenthrine
Dose (g) (a.i. / ha)		spot treatment	12	1000	100	50
Residues / days after last treatement	1	<LOQ	0.018	0.512	0.076	0.31
	4	<LOQ	0.033	0.043	0.080	0.12
	7	<LOQ	0.031	<LOQ	0.095	0.13
	14	<LOQ	0.020	<LOQ	0.086	0.07
	21	<LOQ	<LOQ	<LOQ	0.018	0.13
Current U.E MRL		0.01	0.05	0.5	0.05	0,05

Comply with current EU MRL
No comply with current EU MRL
LOQ = Limit of quantitation

Implementation of experimental programmes and studies

- Identification of pests and study of population dynamics
- Identification of pathogens: correlation of symptoms/pathogens and modes of contamination
- Pesticide efficacy trials
- Characterization of pesticide residue levels on the harvested product as a function of: the dose applied and the delay between the final application and harvest



Fruit fly trap

Transfer of results to actors in the export chain

- Revised technical specifications including a preventative approach to the management of food safety risks and the use of warning systems
- Practical training and technical workshops
- Participation in the Question/Answer forum on the PIP website

Conclusion

Other than the recommendations on pesticide use, the resulting advice allows the rational management of food safety risks based above all on the precise identification of the risks, prevention and warning systems. The proposed technical specifications can also be used to improve the quality of products destined for export as well as for national markets.

CIRAD
Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles
www.cirad.fr

Conception et réalisation : Cirad, Marie Dupuis, département Flhor, February ry 2006

An integrated approach for mango production and quality management

(Mangifera indica cv Cogshall)

Our general hypothesis, on the low yield and the low quality of mangoes, is that mango production and fruit quality are managed mainly by carbohydrates fluxes, at the branch and tree levels. And we considered that tree ecophysiology is a key point to orchard and fruit quality management and that modelling is the adapeted tool to formalize and test our hypotheses. This global approach aims at explaining the effects of interactions between environmental and technical factors within the framework of a global synthetic model.

M. Jannoyer, L. Urban, M. Léchaudel, F. Normand, P.E. Lauri, S. Jaffuel, P. Lu, J. Joas, M.N. Ducamp
Contact: CIRAD FLHOR
TA 50/PS4
Boulevard de la Lironde
34398 Montpellier Cedex 5, France
jannoyer@cirad.fr

Material and methods

Aproach conducted in the experimental station of Cirad Flhor (Saint Pierre, Reunion Island)

Mainly on mango trees, cv. "Cogshall" grafted onto "Maison Rouge"

Adapted biotechnical models from

- **Farquhar biochimical model for photosynthesis**
- **cashoo peach model" for carbohydrates and water fluxes in the fruit:**
- **Fisherman and Génard for biophysical fruit growth**

Factors applied

- **Leaf to fruit ratio**
- **Key phenological stages**
- **Irrigation**
- **Light**
- **Modified atmospheres for the fruit**

Integration of

- **Phenology**
- **Growing conditions (practices)**
- **Environmental factors**
- **Interactions at different scales**

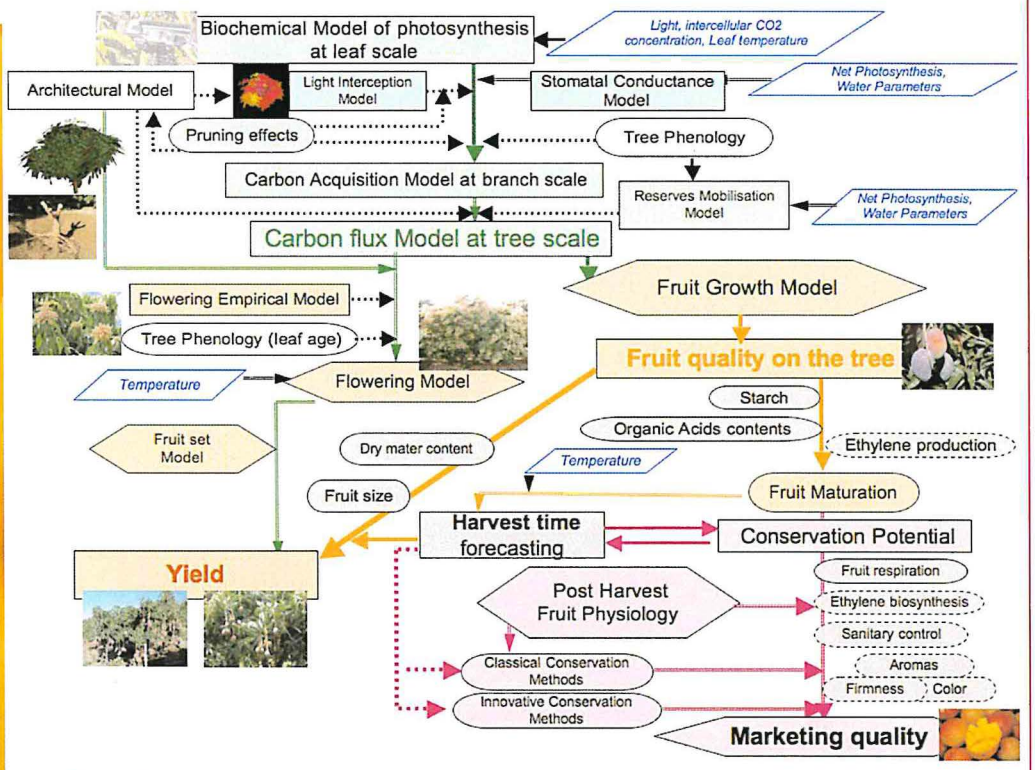
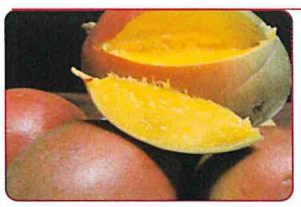


Figure 1. Conceptual model of the relationships between mango tree architecture and physiology, and yield and fruit quality, developed at Cirad Réunion Island. Physiological functions taken in account : Carbon assimilation, Carbohydrates repartition, storage and mobilization,Vegetative growth, Flowering, Fruit growth, Elaboration of fruit quality, Post harvest behaviour



Results

Our global approach is synthesized in Figure 1

- Good simulation of carbon gain at leave scale, integrating the effect of flowering
- No evidence of growth units' succesion leading to flowering and fruiting but interactive effects of fruit load on vegetative growth
- Prediction of fruit quality straits at harvest
  - Fruit fresh mass
  - Dry matter content
  - Major non structural compounds
- Clear relashionship between field quality elaboration and post harvest behaviour

Conclusion

This integrative scheme formalizes the mango tree fuinctionning in the context of tropical humid area.

Next step will consist to integrate the effect and influence of pests and diseases.

INRA

CSIRO

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Centre de coopération internationale en recherche agronomique pour le développement

Département des productions fruitières et horticoles

www.cirad.fr

Conception et réalisation : Cirad, Flhor, Dupuis, département Flhor, February ry 2006

Grafted aubergine for cropping in open fields in the hot rainy season in Mayotte

J. Huat, M.E. Sanial
Cirad, Station agronomique
de Dembéni, BP 1304
97600 Mamoudzou, Mayotte
huat@cirad.fr

Vegetable production is difficult in Mayotte during the rainy season because of the risk of soil waterlogging, high temperature and humidity and soil diseases such as bacterial wilt of Solanaceae caused by Ralstonia solanacearum, of which only race 1, biovar 3, has been identified in Mayotte. Grafted seedling are being used more commonly, especially in Asia, to fight wilt [1–3]. Using the work conducted at INRA in the West Indies [4] and AVRDC in Taiwan [1], we evaluated the impact of grafting aubergine on plant resistance to bacterial wilt and on yields during the rainy season at Dembéni Station (Mayotte).

Material and methods

Material and methods
Three types of aubergine plant laid out in random blocks were monitored under open field conditions or in the open field under shelter:
- plants of the variety 'Kalenda F1', widely grown in Mayotte, grafted on EG 203 ('Surya' variety) originating at AVRDC (Ka on EG);
- 'Kalenda F1' plants grafted on the same variety (Ka on Ka);
- non-grafted 'Kalenda F1' plants (non-grafted Ka).

Planting was performed on 28 November 2003 at a density of 1.1 plants/m^2. We studied plant mortality caused by bacterial wilt, the duration of the vegetation and harvest cycles and also yields.

Results and discussion

Significant differences between the yields of the plants (Ka on EG) (25.5 t/ha) and (Ka on Ka) and (non-grafted Ka) under open field conditions. Even though rainfall was abundant, the stock EG 203 thus gave the plants good resistance to wilt and asphyxiating soil conditions.

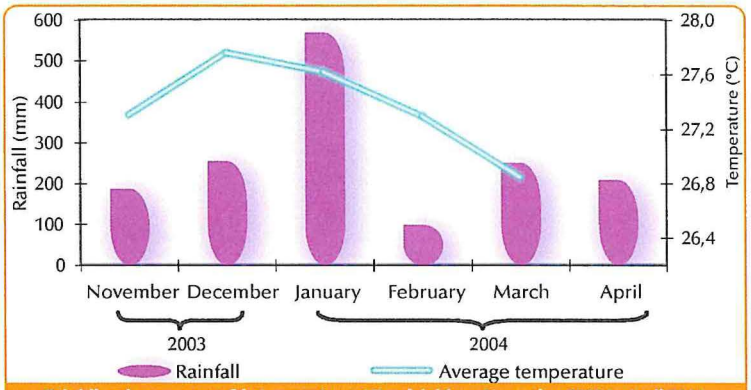
Yields of 'Kalenda F1' aubergine grafted or not on EG 203 under two types of cultivation conditions.

Type of cultivation	Type of plant	Saleable yield (t/ha) Under shelter
	Ka on EG	35.1 ± 5.8
	Ka onKa	41.9 ± 14.5
	Non-grafted Ka	41.0 ± 5.8
Open field	Ka on EG	25.5 ± 4.1 a
	Ka on Ka	6.6 ± 12.2 b
	Non-grafted Ka	3.8 ± 4.2 b

However, resistance is not total as 75% of (Ka on EG) plants had wilted at the end of the harvest under open field conditions. Bacterial mapping of the soil after the harvest showed that *Ralstonia* was very present in the ground, in contrast with the findings for the sheltered plot.

Mortality (%), according to harvesting stage, of 'Kalenda F1'aubergine plants grafted or not on 'EG 203' and grown using two types of cultivation condi-

Type of cultivation	Type of plant	Harvest stage beginning	mid-harvest	end
Under shelter	Ka on EG	0.0	0.0	9.1
	Ka on Ka	0.0	3.0	60.6
	Non-grafted Ka	0.0	3.0	78.8
Open field	Ka on EG	0.0 1	5.3	75.0
	Ka on Ka	44.4	80.6	100.0
	Non-grafted Ka	40.3	93.1	100.0



Rainfall and average monthly temperature at Dembéni from November 2003 to April 2004.

Under shelter, there were no significant differences between the yields of the three treatments (35 to 42 t/ha). Wilt therefore occurred later than in the open field. According to Prior et al. [5], the stability and degree of resistance probably depend on the bacterial strains and environmental factors, and especially high temperature and humidity.

More than 90% of the harvest was marketed; average fruit weight was 300 to 400 g for all plant types.

Other rootstocks resistant to bacterial wilt, such as *Solanum richardii* found growing spontaneously in Mayotte, are currently being evaluated

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Département des productions fruitières et horticoles
Conception et réalisation : Cirad, département Flhor, avril 2005

City food and service supply

The role of coordination in the safe and organic vegetable chains supplying Hanoi

P. Moustier[1], M. Figuié[1], N. Thi Tan Loc[2], H. Thanh Son[3]
[1] Cirad, PCP Malica, UMR Moisa, Cirad Representative Office, 19 Han Thuyen Street, Hai Ba Trung District, Hanoï, Vietnam, paule.moustier@cirad.fr
[2] Rifav, Research Institute on Fruits and Vegetables, Hanoi, Vietnam
[3] Vasi, Vietnam Agriculture Science Institute, Hanoi, Vietnam

The recent economic, politic and demographic changes in Vietnam have led to growing urban demand in quantity and quality. Despite consumers' concern for vegetable safety (especially as regards pesticide residues) and the public and private initiatives taken to promote production and marketing of IPM and organic vegetables, the market for vegetables indicated as safe or organic still represents less than 5% of household consumption in Hanoi - although farmers' profits increase with the marketing of these vegetables. Our objective is to explain this situation by exploring the problems of intra-chain coordination.

Methodology

The unit of our analysis is the leafy vegetables chains produced in Hanoi Peri-Urban Area. Based on a research protocol drawing from insights of institutional economics, we compared different coordination devices (signs, standards, horizontal coordination, vertical coordination) in chains labelled as quality vegetable chains (safe and organic), and in chains of "ordinary" vegetables; we used quantitative and qualitative surveys conducted between 2002 and 2004 on the consumers, traders and producers of leafy vegetables chains supplying Hanoi.

We keep use the term "safe" for the IPM vegetables and the term "organic" for the vegetables produced without any chemical, although this may convey the misled idea that organic vegetables are not safe.

Marketing chains of leafy-vegetables in Hanoi.

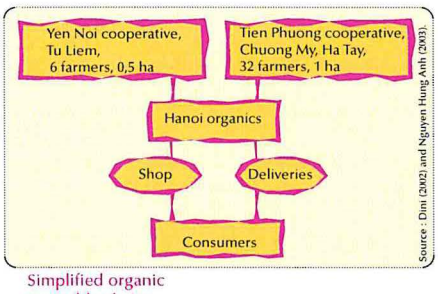
Coordination in ordinary chain

1. Absent signs and standards : ordinary vegetables, without indication of quality, constitute more than 95% of vegetables sold in Hanoi wholesale and retail markets.

2. Vertical coordination: mainly spot relationships.

3. Absent horizontal coordination: peri-urban farmers are involved in cooperatives, but, for ordinary vegetables, these cooperatives deal mostly with infrastructures, e.g., irrigation, and are not involved in marketing, which takes place on an individual basis.

4. Quality control is mostly organised in an internal way within the cooperatives; only the organic vegetable company has recourse to an external body.



Simplified organic vegetable chain in Hanoi in 2002.

Coordination in organic chains

1. Attempts at certified quality signs. This certification is awarded by "Organic Agricultural Certification Thailand". Yet, this certification has been interrupted from June 2004 onwards due to financial diffic ulties of the company.

2. Vertical coordination: Hanoi Organics Company signs 2-year contracts with six families of producers in Hanoi province, and 32 farmers in Ha Tay province, specifying the production regulations and frequency of controls, while quantities and prices are renegotiated every 3 months.

3. Limited horizontal coordination : no collective action among producers, i.e., as regards the grouping of sales, or quality control, which created some dependence between the farmers and the marketing company, and problems of adequate coordination between farmers and the company staff.

Conclusions and perspectives

The comparison of ordinary and quality vegetable chains (safe and organic) confirms the proposition that integrated forms of coordination and farmers' collective action are the most developed in chains with the highest share of vegetables getting a premium for quality, together with the presence of signs and the reference to quality standards.

Recommendations at the State level are indicated below:

1. Defining minimum non-toxicity standards and ensuring they are respected.

2. Supporting definition and control of compliance with private standards, notably via laboratory accreditation.

3. Providing information concerning the advantages and disadvantages of various methods of coordination.

Safe vegetables in a row of a supermarket in Hanoi.

Full paper prepared for ISHS supply chain seminar, 19-23 July, Chiang Mai, based on results of a Cirad-Inra project on "coordination and quality", and Susper project, funded by French Ministry of Foreign Affairs.

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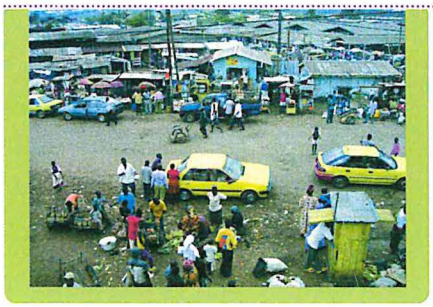
Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, avril 2005

Periurban horticultural dynamics: the case of a small town in south-west Cameroon from 1995 to 2004

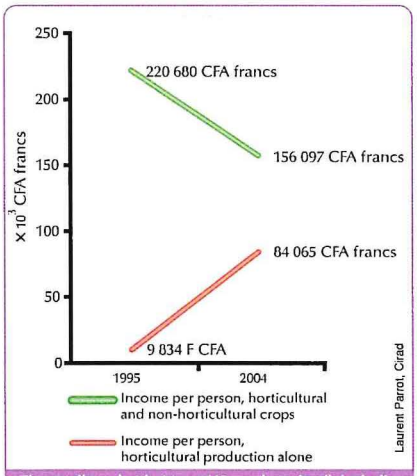


L. Parrot, économiste
Cirad, BP 2572, Yaoundé, Cameroun
L. Nounamo, agro-économiste
Irad, Yaoundé, Cameroun
R. Kahane, agronome
Cirad, département Flhor, TA50/PS4, 34398 Montpellier 05, France
A. Nantchouang, statisticien
Ins, Yaoundé, Cameroun
parrot@cirad.fr

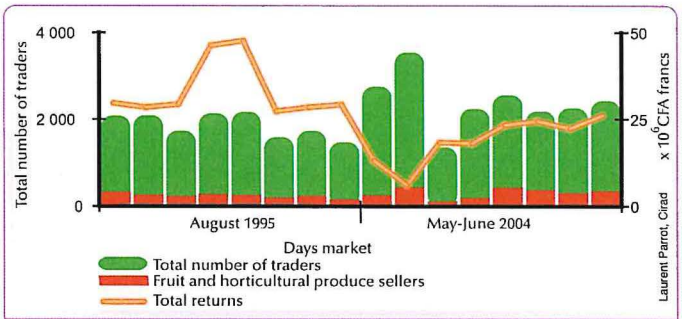
PERIURBAN horticultural crops generate large returns and are replacing root and tuber production. This is revealed by the first results of a series of surveys conducted between 1995 and 2004 in a town at the foot of Mount Cameroon in south-west Cameroon.

Results

The town of Muea some fifty kilometres from Douala and its port has a population of about 10,000. It is typical of many towns of the same kind scattered through western and south-western Cameroon. The first results of the survey conducted from 1995 to 2004 show that most indicators of the living conditions of households improved, and especially incomes, accommodation and education. However, the details show that the proportion of income earned in agriculture has fallen by 30% to the benefit of emerging urban occupations, and especially services in the informal sector. This is the result of the urbanisation of the secondary towns in Africa and increased density of the urban fabric. Income from horticulture has a major position in household farming activities as returns from this occupation increased nearly ten-fold during the same period and now form more than half of the agricultural incomes of families. The 1995 and 2004 surveys consisted of (a) a detailed population census, (b) a survey of a sample of households, (c) a survey at the local market, and (d) a survey of the 80 tontines in the town. The results show that although the size of the population remained comparatively stable from 1995 to 2004, the number of dwellings practically doubled, which might be explained by an increase in the number of house owners and by 'return migration' from the large urban centres (retired people).



The retail market in Muea (48 products in all, including 26 agricultural products)
Sources: surveys at the market in 1995 and 2004.



Decrease in growing roots and tubers to the benefit of horticultural produce
Sources: surveys of households in 1995 and 2004.

The 1995 and 2004 surveys found 13 horticultural products in a total of 26 agricultural products including coffee and cocoa. With the exception of cash crops that have specific sectors, all this produce was sold on Muea market. This is a place for meetings and business that assembles an average of 2000 tra-

Partnerships

Investigations were performed in 2004 within the framework of the PCP-Grand Sud Cameroun (Research Co-operation Partnership) coordinated by CIRAD, IRAD (Institut de Recherche Agricole pour le Développement), the Faculté d'Agronomie de Science Agricole (FASA) and the University of Yaoundé. The operational phases were conducted with the support of the University of Buea, the Buea Délégation provinciale de statistique (Provincial Statistics Delegation) and the Institut national de statistique (National Statistics Institute) in Yaoundé. In 1995, operations were supported by the OCISCA programme (Observatoire pour le Changement et l'Innovation Sociale au Cameroun), IRD (Institut de Recherche pour le Développement) and the Ministry of Foreign Affairs.

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Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, avril 2005

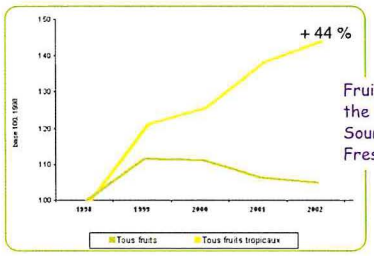
High added value products

The European exotic fruit market: constraints and opportunities

Eric Imbert
Cirad, Observatoire des marchés du département Flhor, TA 50/PS4, 34398 Montpellier Cedex 5
imbert@cirad.fr

Imports of fresh fruits to the European Union totalled 8.2 million tonnes in 2002 and 10% of this consisted of tropical fruits (excluding banana). These imports have increased strongly and steadily since 1998.

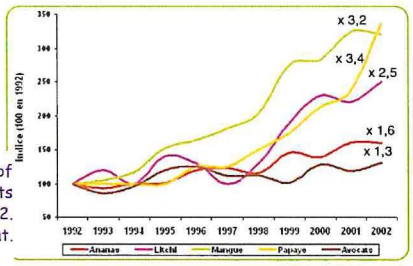
Tropical fruit consumption in the EU: strong, steady increase.



Fruit consumption in the EU
Source: Eurostat, Freshfel.

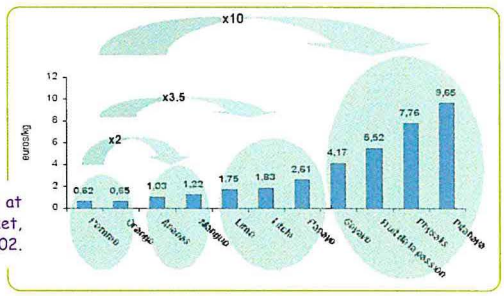
Les principaux fruits tropicaux importés dans l'UE

Category	Fruit	Imports (t) annual scale of size
Except	Banana	4 000 000
Classic, major	Avocado	155 000
	Pineapple	370 000
	Mango	140 000
Emerging, minor	Litchi	25 000
	Papaya	27 000
Niche, little known	Passion fruit	100-1 000
	Pitahaya	
	Guava	
	Mangosteen	
	Durian...	



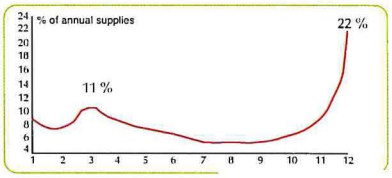
Evolution of European imports 1992-2002.
Source: Eurostat.

Tropical fruit consumption hampered by the high cost of air freight.

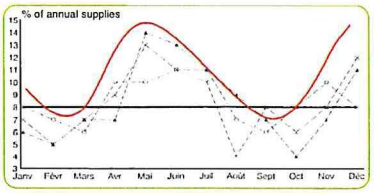


Wholesale prices at Rungis market, France, in 2002.

The markets are very seasonal, even for the major exotic fruits.
Sales are increasing strongly during the Christmas period, at Easter and, more recently, for the Chinese New Year.

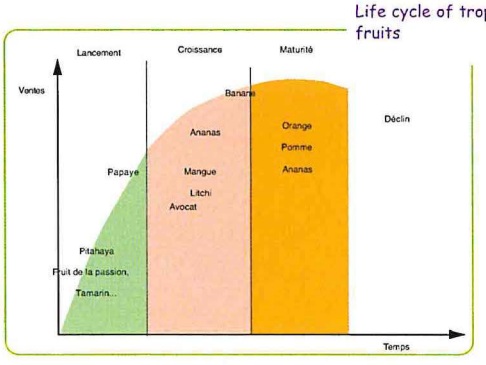


Monthly pineapple and mango sales in Europe



A life cycle similar to that of manufactured goods.

Life cycle of tropical fruits



Market characteristics specific to each kind of fruit.

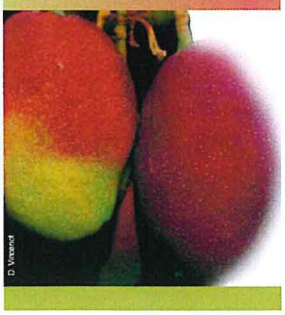
Category	Major	Minor
Consumption	Large Steady with seasonal peaks	Niche market Seasonal
Price	High, but accessible	Luxury products
Transport	Sea	Air
Sector	Traditional (with middleman) Sometimes integrated (from production to distribution)	Traditional (with middleman)
Distribution	Mass in supermarkets Specialised retailers	Sometimes in supermarkets Specialised retailers

Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, avril 2004

Growth and fruit quality constitution in mango

Mathieu Léchaudel
Cirad, station de Bassin-Plat, BP 180,
97455 Saint-Pierre Cedex, Réunion
lechaudel@cirad.fr



The effect of the availability of water and carbon on the physiological processes that are involved in the constitution of mango size and organoleptic quality was studied to contribute to explaining the strong variability of the quality of fruits on the same tree. Our approach (Figure 1) was aimed at:

- *analysing, under contrasted water and carbon supply conditions, the carbon and water supplies of mango that enable growth;*
- *incorporating these results in a model forecasting fruit characteristics at harvesting (fresh weight, taste quality, indicators of length of storage).*

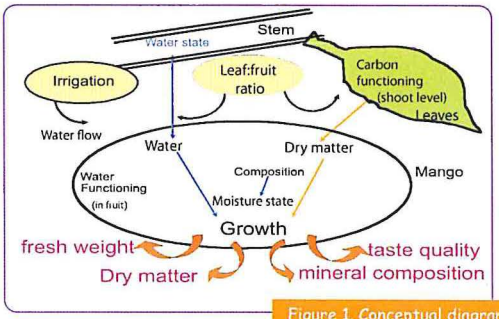


Figure 1. Conceptual diagram for analysis of the constitution of quality in mango.

Procedure

The procedure developed is aimed at incorporating in models knowledge gained from experimental work on physiological processes. The fruit-bearing shoot is chosen as the working scale as this bears the fruits and leaves in which uptake takes place. The effect of carbon availability on source-sink relations at fruit-bearing shoot level was studied experimentally and then modelled. The model incorporates the processes of photosynthesis, maintenance and growth respiration, the development of leaf and wood reserves and fruit growth.

Determination of the moisture state of mango pulp tissue and hourly variations in fruit growth made it possible to study and model the water functioning of mango by introducing variables related to elasticity and plasticity properties of the tissues. Variation laws are proposed for these variables for mango.

Results

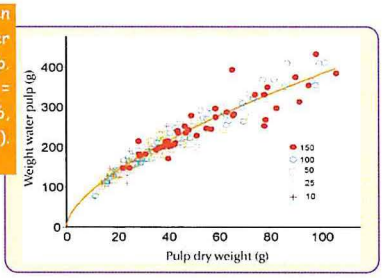
A descriptive approach was used to demonstrate a strong link between accumulation of moisture and dry matter in each part of the mango fruit (skin, pulp and seed) (Figure 2). It appeared that the pulp is the compartment that increases most with the leaf: fruit ratio. We showed that fresh weight and pulp dry mater are the main quality criteria to be influenced by the carbon supply (Table 1).

The moisture functioning model of mango shows the reversible and irreversible growth variations observed (Figure 3).

Tableau 1. Comparison of simulated and observed fresh weight and dry matter in mango.

Treatment	Fruit fresh weight (g)		Dry matter content (%)	
	observed	simulated	observed	simulated
25	373,2 ± 63,8	425,53	17,54 ± 3,62	17,1
50	436,4 ± 62,5	436,10	18,54 ± 2,21	17,47
100	587,2 ± 43,6	477,10	20,47 ± 0,83	18,38

Figure 2. Relation between the water and dry matter accumulation in mango pulp. ($Water_{pulp}$ = 20,5617.MS0,6336, R2 = 0.93; P_{value} < 0.01).



Conclusion

The models of carbon and moisture functioning were incorporated in an overall model for forecasting a quality profile; this gives fairly accurate simulation of the fresh weight (Figure 4), the dry matter content (Table 1) and the concentrations of the main biochemical compounds in the sweet and acid characters related to fruit conservation.

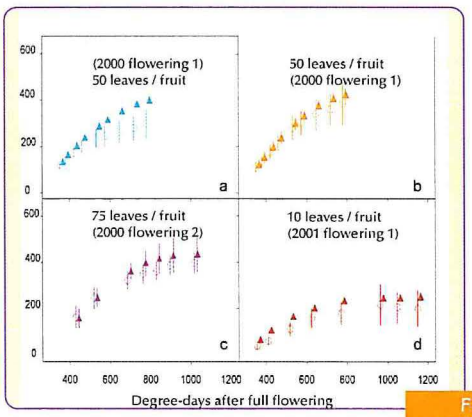


Figure 3. Simulated growth (Δ) and observed growth (○) in fresh weight of mango.

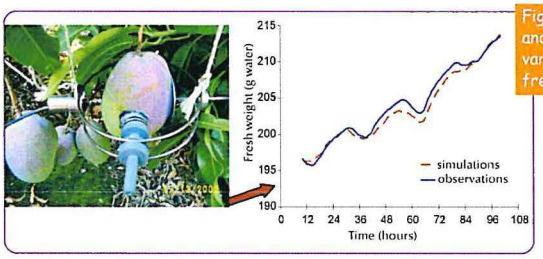


Figure 4. Simulated and observed variations in mango fresh weight.

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Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, avril 2004

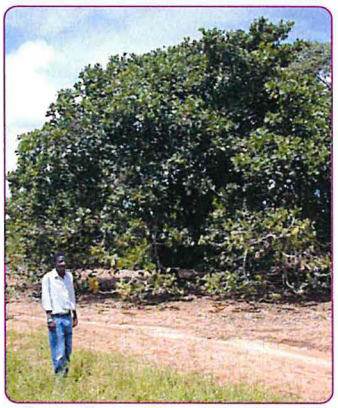
Project for the re-launching of the cashew sector in Nampula province, Mozambique

Jean-Paul Lyannaz,
INIA/Cirad, Coordinator Cashew Applied Research Project, Nampula Mozambique
lyannaz@cirad.fr

This project is funded by AFD (Agence française de développement). It is conducted jointly by INIA (Instituto National de Investigaco Agronomica, Mozambique), who subcontracted the 'Applied research' component to CIRAD, and INCAJU (Instituto fo Fomento do Caju, Mozambique), the project manager.

Project objectives

Raw cashew nut production in Mozambique peaked at 216,000 tonnes in 1972 before falling to less than 22,000 t in 1989/1990. Current production is between 56 000 and 60 000 t. The aim of the project was to accompany the re-launching of cashew production.
A review of the situation was followed by the undertaking of various research, development and training actions.



Support for development actions

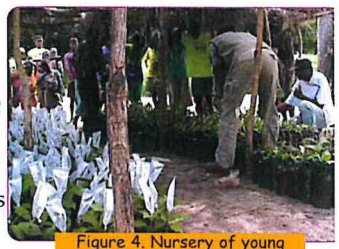


Figure 4. Nursery of young cashew seedlings for use in setting up multisite trials.

– Training of technicians and farmers (agrotechnics and nurseries).

– Supply of plant material for nurseries and support for the setting out of clone gardens (Figure 4).

– Setting up multisite demonstration trials.

Figure 1. Chemical spraying to control powdery mildew.

Applied research programme

Phytosanitary protection

• Disease control

Control of powdery mildew disease (Figures 1 and 2):
– replacement of triazoles, in particular by FLINT (trifloxistrobin),
– demonstration of the effectiveness of low-cost generic triazoles,
– integrated control.

Control of anthracnose:
– development of a method for the evaluation of the degree of infestation by the disease (Figure 2),
–performance of fungicide trials using:
• FLINT (trifloxistrobin): high efficacy,
• ORTIVA (azoxistrobin): good efficacy
• SCORE (difenoconazol).

Figure 2. Cashew shoots attacked by anthracnose and powdery mildew.

FLINT has the twin advantage of excellent efficacy in the control of powdery mildew and anthracnose.

• Pest control

Control of *Helopeltis* sp., Miridae (Figure 3), the main pest, and *Pseudoterapus waii* (Coreidae):
– chemical control is possible [Karate (lambda-cyhalothrin)],
– biological control to be developed using ants *Oecophylla* spp.

Varietal selection

– Selection and monitoring of local clones using the criteria of number of inflorescences, nut and kernel yields and tolerance/resistance to powdery mildew, anthracnose and *Helopeltis*.
– Multisite genotype-environment trials in three provinces (64 clones tested).
– On-farm behaviour trials (common and dwarf types).
– On-station monitoring of 140 clones.

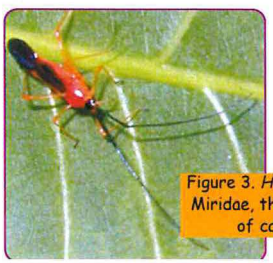


Figure 3. *Helopeltis* sp., Miridae, the main pest of cashew.

Training national researchers

– Training in Brazil (EMBRAPA) of a genetic engineer (varietal improvement).

– Training in Tanzania (NARI) of an engineer level entomologist.

– Special relations with NARI (National Research Institute of Naliendele, Tanzania).

Conclusion

All the research results obtained or to be improved are aimed at enhancing integrated management of cashew by the transfer of production technologies to farmers in Mozambique by means of various actions:
– the rationalised use of fungicide to control powdery mildew disease,
– phytosanitary pruning to reduce inoculum sources,
– biological control of *Helopeltis*,
– field cleaning,
– control of bush fires,
– planting good quality grafted seedlings,
– selective elimination of unproductive trees,
– top grafting practice,
– intercropping with annual crops,
– setting up and managing community or private nurseries.

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Département des productions fruitières et horticoles

Conception et réalisation : Cirad, département Flhor, mai 2004

Prevention of postharvest browning of litchi by soaking in an acid solution: effect of application conditions and performance of the treatment

J. Joas, Y. Caro, M. Leblanc
Cirad, BP 20, 97408 Saint-Denis Cedex

Several acid dip treatments were performed to stabilise the red colour of litchi shells. The most promising results were given by a combination of citric acid and chitosan (M.N. Ducamp). Transposition to a larger scale gives varying results, leading to supposing that a

Method

Different conditions of application of acids (pH, immersion time, temperature) were compared according to the different physiological states of the shell. Treatment performance was codified by monitoring of pH values and shell titratable acidity combined with a browning score.

Results

Incidence of the dips

The results of the treatment naturally depend on the initial pH (Figure 1); the immersion time has little effect. Monitoring of phenols and anthocyanins showed that the acidification level slows phenol oxidations and degradation of anthocyanins Figure 2).

The shell browning rate depends on the pH, the degree of drying and enzymatic activity; phenol oxidation induces the formation of o-quinones that initiate the breakdown of anthocyanins. At a given temperature, the expression of browning depends on the combined evolution of the shell pH and the degree of drying.
The acid impregnation coefficient Ia, defined as the ratio of titratable acidity to percentage postharvest weight loss, gives a dynamic appraisal of this link. The evolution of browning according to Ia shows the incidence of the pre-treatment moisture content (Figure 4). The threshold value of coefficient Ia at which harmful browning occurs is positively correlated with storage temperature as enzymatic activity also depends on temperature.

These results provide some information about the sometimes unforeseeable performance of fruits subjected to the acid treatment. The ongoing research also shows that the stage of maturity of the fruit may influence the rate of browning (unpublished data).

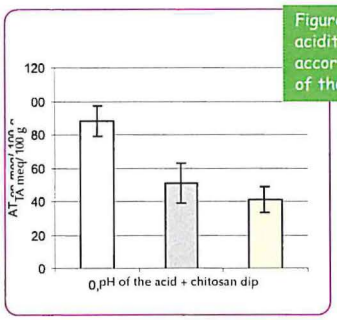


Figure 1. Titratable acidity in the shell according to the pH of the dip.

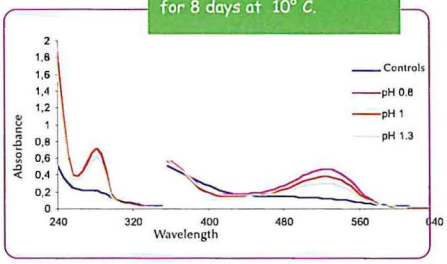


Figure 2. Phenol (280 nm) and anthocyanin contents (527 nm) of litchi shells after storage for 8 days at 10° C.

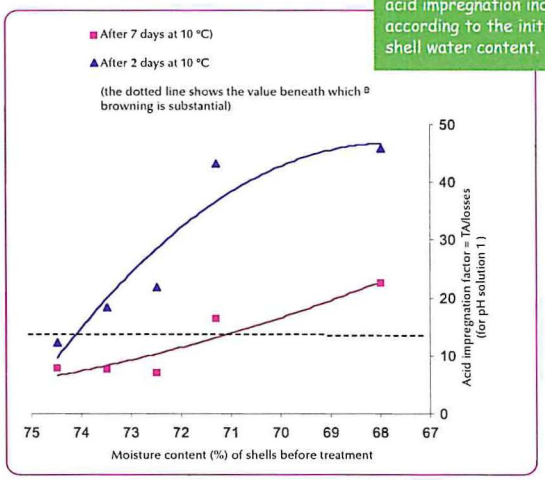


Figure 4. Evolution of the acid impregnation index according to the initial shell water content.

Incidence of shell moisture content

The initial shell moisture content affects the degree of acid impregnation. Partial drying of the shell resulting simply from storage before treatment improves the acid coating. This drying can be controlled by using a chart (Figure 3).

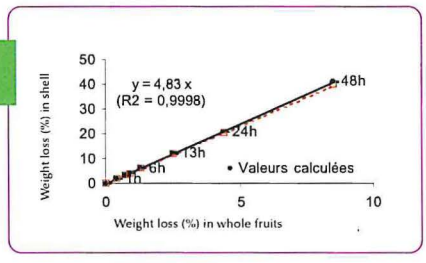


Figure 3. Shell dehydration chart.

Prospects

Combining stages of maturity, the degree of pre-harvest drying, the postharvest drying rate and storage temperature, the study of browning planned for the next season should provide sufficient information for the accurate identification of the factors of variability of response to the treatment.

CIRAD
Centre de coopération internationale en recherche agronomique pour le développement
Département des productions fruitières et horticoles
Conception et réalisation : Cirad, département Flhor, avril 2004

Do chloroplastic PCR markers fit with Aurantioideae evolution ?

Ollitrault P.[1], Lotfy S.[2], Froelicher Y. [4], Dambier D.[1], Navarro L.[3], Luro F. [4]
[1] Cirad-Flhor, TA50/PS4, Boulevard de la Lironde
34398 Montpellier Cedex 5, France
[2] Inra, Station d'El Menzeh, BP 293, Kénitra, Maroc
[3] IVIA, Ctra Moncada-Naquera, Km 4,5, Apartado Oficial
46113 Moncada, Valencia, Spain
[4] Station de recherches agronomiques (SRA) / INRA/CIRAD, 20230 San Giuliano, Corse, France
Contact: patrick.ollitrault@cirad.fr, dominique.dambier@cirad.fr

Genetic information on plant chloroplastic DNA presents a great interest because their uniparental origin and theoretical low evolution rate make it particularly adapted for phylogenic studies at interspecific and intergeneric levels. Moreover, in citrus the making of numerous somatic hybrids required tools to characterize their cytoplasmic genome, and the development of new PCR markers appeared very suitable. The application of Cleaved Amplified Polymorphic Sequences (CAPS) method with universal primers has been recently demonstrated to be efficient at the interspecific level but it displays weak diversity at the infraspecific one (Lotfy et *al.*, 2003a). Genetic markers based upon simple sequence repeats (SSR) in chloroplastic genomes (CpSSR) have been shown to be useful markers in several plant species such as rice (Ishii and Couch, 2000) and Solanaceous (Bryan *et al.*, 1999; Weising and Gardner, 1999). These CpSSR are characterized by mononucleotide repeats. The transportability to citrus of primers defined from rice and tobacco has been recently proven (Lotfy *et al.*, 2003b). In the present work, we compare the traditional botanical classifications of Aurantioideae subfamily (Figure 1) with the ones obtained with these two kinds of chloroplastic markers PCR.

Organization of chloroplastic CAPS diversity among Aurantioideae subfamily

Four couples of chloroplastic universal primers (Demesure *et al.*, 1995) revised for citrus by Lotfy et al. (2003a) have been combined with two to four restriction enzymes [psaA/trnS3 (HindIII, EcoRI, Hin6I), trnT3/trnD2 (DraI, Bsp143I), trnC2/trnD1 (HaeIII, EcoRI), trnM/rbcL (MvaI, Eco130I), trnH/trnK3 (Mva1, AvaII, HaeIII, DraI)] and analyzed in agarose gels (Figure 2). NJ tree was established from Sokal and Michener's distances based on the profiles observed for theses 13 primers/enzymes combinations (Figure 3).

Organization of CpSSR diversity among Aurantioideae subfamily

Eight couples of primers from tobacco [ccmp1, ccmp2, ccmp4, ccmp5, ccmp6, NTCP7, NTCP9, NTCP28 (Bryan *et al.*, 1999; Weising and Gardner, 1999) have been used for a diversity analysis among 50 species of Aurantioideae sub-family (germplasm from SRA and IVIA collections). 5'-end γP^{33}]-radiolabelled primers have been used for PCR, and migrations were done in sequencing gels (Figure 4). We observed that NTCP7 and ccmp2 primers amplify a same cpSSR locus, so NJ tree was established from Sokal and Michener's distances based only on seven locus (Figure 5).

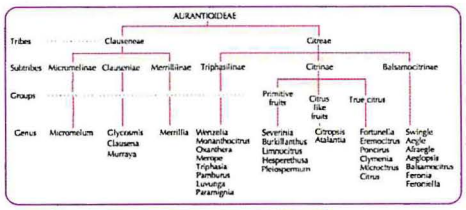


Figure 1. Botanical classification of Aurantioideae subfamily.

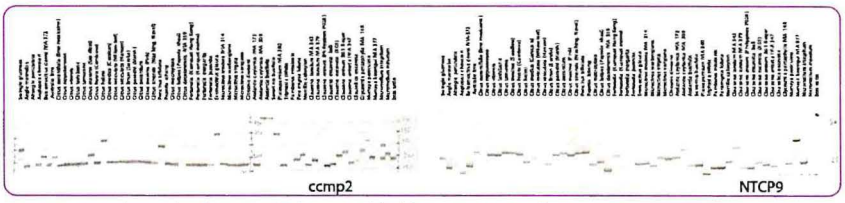


Figure 4. Autoradiography of two CpSSR locus amplified from 50 Aurantioideae species.

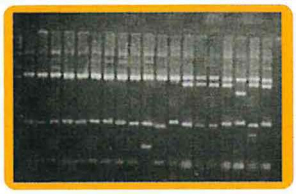
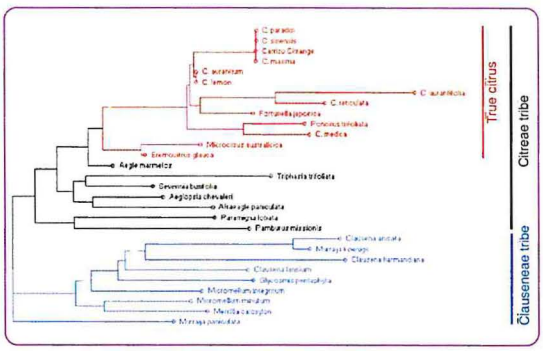


Figure 2. Agarose electrophoresis of citrus DNA amplified with trnH/trnK3 primers and restricted with Mva1 enzyme.

Figure 3. NJ tree analysis established from thirteen chloroplastic CAPS profiles.



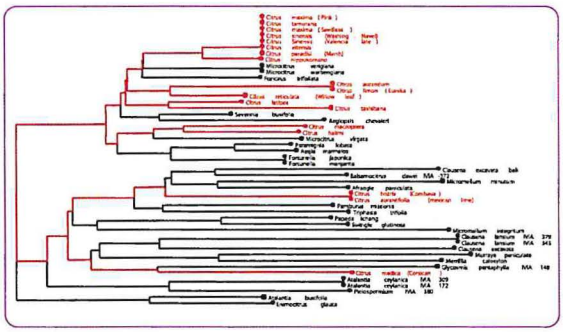


Figure 5. NJ tree analysis established from seven CpSSR locus.

Discussion

The two kinds of markers display similar genetic organizations for the cultivated species of the *Citrus* genus. No differentiation was possible between *C. limon* and *C. aurantium* and no more between *C. maxima*, *C. paradisi* and *C. sinensis*. The differentiation between *C. medica*, *C. reticulata* and *C. maxima* is in agreement with the one observed for the nuclear genome. With respect of the generally admitted status of these species as ancestors of the cultivated forms, it appears that *C. maxima* has been implied as the female parent in the genesis of *C. sinensis* and *C. paradisi*. The high differentiation of *C. aurantifolia* with all other cultivated *Citrus* demonstrated that an additional species has been implied in the lime evolution. *C. hystrix* displays the same profile than *C. aurantifolia* for CpSSR markers as in the Nicolosi *et al.* (2000) chloroplastic CAPS analysis. These authors suggested that a third species with the same CAPS chloroplastic profiles, *C. micrantha*, was a progenitor of limes. At the intergeneric level, the structuration of CAPS diversity is very coherent with the botanical classification with a cluster grouping the true citrus genus and some clear differentiation between the Citreae tribe and Clauseneae tribe. At the opposite, CpSSR clustering is not in agreement with traditional taxonomy. *Citrus* species appear dispersed in the different clusters of the NJ tree. The evolution mode of this kind of markers associates microsatellite evolution but also insertion or deletion. The first one having a much higher evolution rate than the other ones, it is not suitable to infer genetic distances directly from fragment size variations. CpSSR fragments should be sequenced to allow a better phylogenetic interpretation. It is also possible that CpSSR evolution is too rapid to use to this kind of markers for broad intergeneric studies. CAPS analysis should be preferred for such applications. CpSSR should be recommended to differentiate chloroplastic genomes of related species and as routine tool for the chloroplastic characterization of somatic hybrids.

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Reintroducing agrobiodiversity to design more sustainable banana cropping systems in the French West Indies

Malezieux [1] E., Dorel [2] M. Tixier [2] P., Ganry [3] J.,
[1]CIRAD, UMR SYSTEM, TA179/01, 34398 Montpellier Cedex 5, France.
[2]CIRAD-Flhor, UMR SYSTEM, 97130 Capesterre – Guadeloupe, France
[3]CIRAD-Flhor, 34398 Montpellier Cedex 5, France

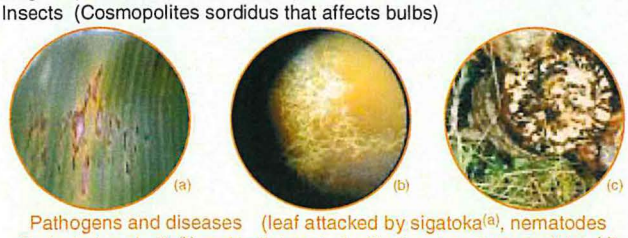
In most banana producing countries, banana production for export is based on intensive monocropped, monospecific and monocultivar systems that require high chemical inputs and frequent plantings to obtain a steady production. In the French West Indies Guadeloupe or Martinique (16°15'N, 61°32'W), the monoculture of banana (Musa spp., AAA group, cv. Cavendish Grande Naine) requires several applications of fongicides, nematocides, insecticides and herbicides per year, frequent plantings (pests reduce yields and increase plant falls due to poor root system). These practices can thus lead to serious threats to air, soil and water quality, with major detrimental impacts. These risks are magnified in fragile ecosystems such as tropical islands where inhabited areas, coral reefs and rainforests are located close to agrosystems. Designing more sustainable agricultural systems appears hence as a key ecological and social challenge. In this context, reintroducing agrobiodiversity at different scales (plot, farm, region) could provide a solid foundation for designing more sustainable alternative systems.

The impacts of intensive monoculture

Agronomical sustainability

Long-term monoculture leads to the high parasite pressure wich is responsible for high pesticides use and hence pollution.

- Fongi (Mycosphaerella musicola responsible of Sigatoka disease)
- Nematodes (Radophollus similis, others phytoparasitic nematodes and fungi responsible for roots lesions)
- Insects (Cosmopolites sordidus that affects bulbs)



Pathogens and diseases (leaf attacked by sigatoka[a], nematodes Radopholus similis[b] and bulb invaded with Cosmopolitus sordidus [c])

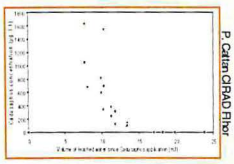
Threats for environment

Air

Air fungicide application to control sigatoka

Soil

High erosion risks on plowed and uncovered soil



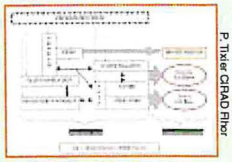
P. Cattan CIRAD Flhor

Water

Pesticide in leaching water constitute a serious threat for ground and surface waters

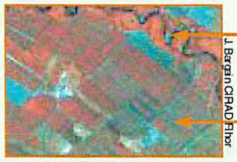
Tools to assess and design cropping systems

- Models and indicators are built to assess and prototype new cropping systems (Model SIMBA). These tools helps to define new sets of practices and to optimise rotations.
- Use of remote sensing to assess crop stages and diversity at the region scale.



P. Tixier CIRAD Flhor

SIMBA model structure



J. Bargain CIRAD Flhor

Satellite image

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Tixier, P., Malézieux, E., and Dorel, M., 2004. SIMBA-POP: a cohort population model for long-term simulation of banana crop harvest Ecol. model. In press.

The role of agrobiodiversity to design more sustainable systems

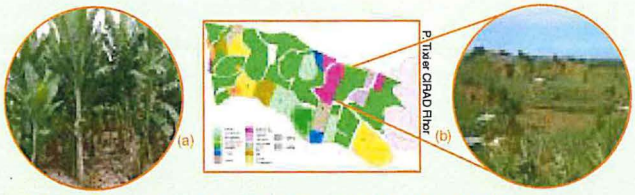
As a preliminary strategy, fallows, cover crops and rotation crops such as sugarcane, pineapple or forage have been introduced in these systems and could be an effective way to improve pest and weed control, while reducing pesticide use and erosion.

Biodiversity management over space and time.

Agrobiodiversity through its complex interactions with the cultivated crop, the pathogens and the components of the environment, play an important role in the functioning and resilience of systems. Reintroducing biodiversity at different scales of time and space is a credible alternative to monoculture.

Pest control : use of non inoculated material (banana vitroplants) after fallow[a], rotations with sugar cane[b] or pineapple[c] allow a better control of nematodes and decrease nematocide use.

Weeds control and beneficial impacts : Covercrops such as Impatiens. sp.[a], or sugar cane residues[b] used as much allow a better contrôl of weeds, a decrease of herbicide use and a better contrôle of erosion and water transfert.



P.Tixier CIRAD Flhor

Diseases control: New hybrids resistant to Sigatoka[a] are under development. Epidemiologic risks: Spatial arrangement of species at field and farm scale[b] may reduce these risks.

Conclusion

The sustainability of future banana-based cropping systems will depend on our ability to combine agro-technological innovations, field management strategies and enhanced knowledge on the functional ecology of these systems. Further ecological studies are required to improve the knowledge of the ecology of these new agrosystems.

UMR System

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SIMBA: a comprehensive model for agro-ecological assessment and prototyping of banana-based cropping systems. An application in the French West Indies.

P. Tixier[1], E. Malezieux[2], M. Dorel[1], J. Wery[3]
[1] CIRAD-Flhor, UMR SYSTEM, 97130 Capesterre, Guadeloupe, F.W.I., France.
[2] CIRAD, UMR SYSTEM, TA179/01, 34398 Montpellier Cedex 5, France.
[3] Agro-Montpellier, UMR SYSTEM, TA179/01, 34398 Montpellier Cedex 5, France.

Monospecific banana (Musa spp., AAA group, cv. Cavendish Grande Naine) based cropping systems may present important threats for the environment. In these agrosystems, pesticides cause significant risks of pollution for surface and ground water, especially in the tropical insular conditions of French West Indies. In order to asses these risks and to help design more sustainable cropping systems a specific model called SIMBA was built. SIMBA simulates banana cropping systems through several cropping cycles. It includes sub-models that simulate soil structure, water balance, root nematode populations, yield, economic outputs. Agri-environmental indicators linked to the model allow assessment of potential environmental impacts. The model has been implemented in Guadeloupe (F.W.I. , 16°15'N, 61°32'W) and allow practical recommendations to farmers, virtual test of agro-technological innovations or management strategies at field level.

The challenge of banana based cropping systems in F.W.I.

Environmental: pollution of water by pesticides, erosion
Agronomical: sustainability due to loses of fertility, development of nematodes
Economical: fluctuation of market price,
→There is a need for new innovative banana based cropping systems, we propose a complete tool to assess and generate such systems

Requirements for the model

- Simulate crop rotations and nematodes dynamics
- Take into account the specificity of the banana crop (evolution of the plant population structure)
- Calculate agronomic, environmental and economic outputs
- Biophysical model driven by decision rules

Structure of SIMBA

• **Biophysical sub-models** that simulate plant growth, plant population structure (cohort population concept, Tixier et al. 2004), physical soil properties, water balance, dynamic of multi species nematode population.

• **Qualitative models of environmental impacts** (based on expert system and fuzzy logic, Girardin et al. 1999) that lead to **indicators** notes.

• **Inputs**: climate, soil properties and farmers' practices via decision-rule processes (managed through a decision rules generator).

• **Outputs**: agronomic performance (yield, pest), economic results (profit margin) and environmental assessment (indicators of exposure of water to pesticides, erosion and soil quality)

• **Weekly step** simulations at the **field scale** on the **long term**. Developed on STELLA® software environment (HPS®)

• **Calibration** and **validation** of most module with data from Guadeloupe

Uses of SIMBA

Multicriterion assessment

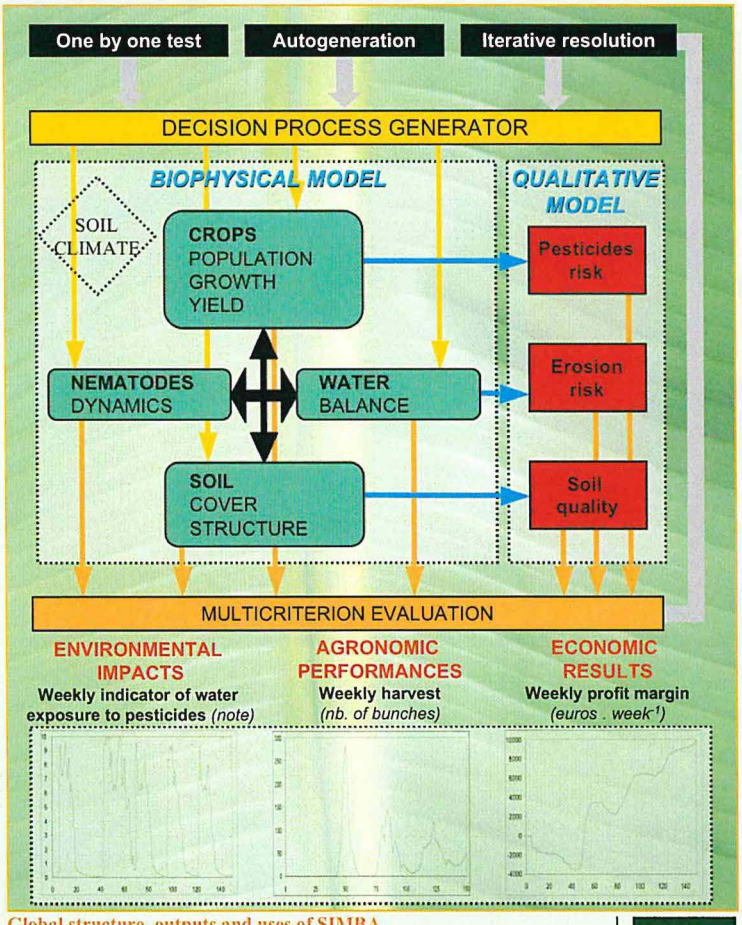
• **Detect** periods of risk of water pollution and erosion
• **Compare** cropping systems (rotation and crop management)

Cropping system prototyping

• **Test** of tactical or strategical decision rules sets (**one by one test**)
• **Sort and select** the best sets of decision rules that fit to objectives (minimizing environmental impacts, maximizing economic margin or a trade off between these two objectives) by an **autogeneration** of a large number of sets of decision rules or an **iterative resolution**.

Conclusion

SIMBA is a powerful tool to aid to prototype new cropping systems, it allows a multicriterion assessment of different crop management strategies in order to come up with practical recommendations to assist farmers, regarding the efficiency of new agro-technological innovations and field management strategies. **The global and long term approach allows realistic solutions to agronomic or environmental problems that are not possible with existing crop models.**



Global structure, outputs and uses of SIMBA.

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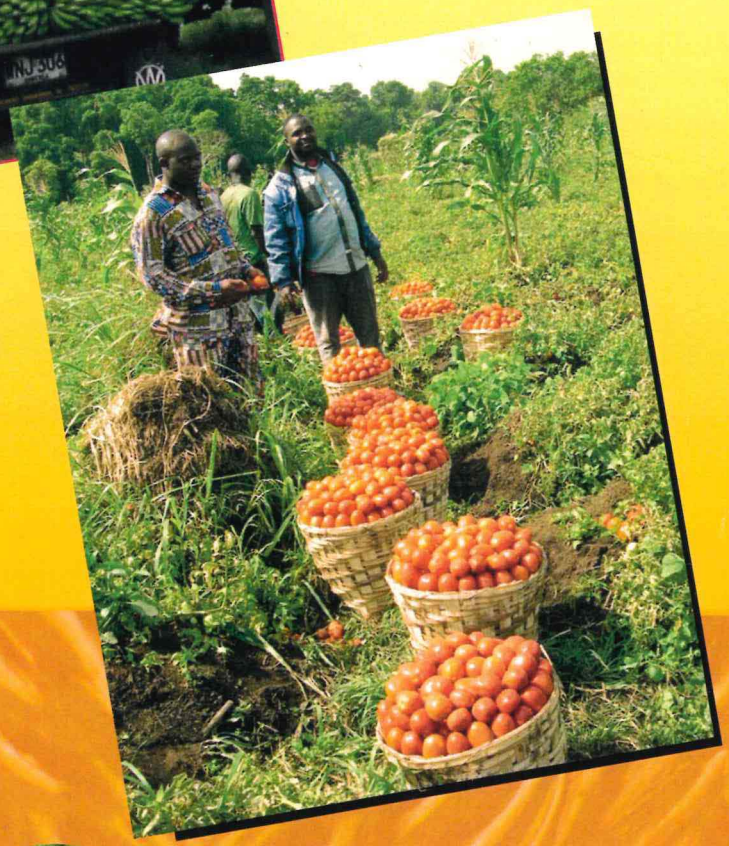

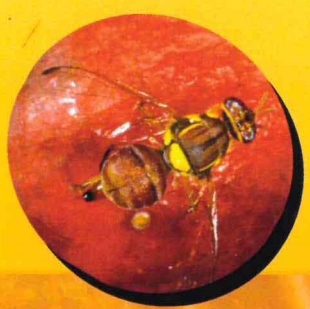

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Centre
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Département
des productions
fruitières
et horticoles

Boulevard de la Lironde
TA50 - PS4
34398 Montpellier
Cedex5, France

dirflhor@cirad.fr

Conception et réalisation : Cirad, Martine Dupontel, département Flhor, March 2006