Azadi Ka Amrit Mahotsav

3rd International Weed Conference

"Weed problems and management challenges: Future perspectives"

3rd IWC - 2022

Indian Society of Weed Science

20-23 December, 2022

Venue: Anand Agricultural University, Anand, Gujarat, INDIA

Proceedings

Supported by

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Organizers

Indian Society of Weed Science

Anand Agricultural University

ICAR - Directorate of Weed Research

Indian Council of Agricultural Research

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Correct citation of proceedings:

Rao AN, Dubey RP, Sondhia Shobha and Yadav Ashok (Eds.). 2022. *Proceedings of 3rd International Weed Conference on "Weed problems and management challenges: Future perspectives"*, Anand Agricultural University, Anand, Gujarat, India. 355 p.

Correct citation of abstract in proceedings:

Author (s). 2022. Title of the abstract........ P. .... In: *Proceedings of 3rd International Weed Conference on "Weed problems and management challenges: Future perspectives"*, (Eds. Rao AN, Dubey RP, Sondhia Shobha and Yadav Ashok), Anand Agricultural University, Anand, Gujarat, India.

Technical support & cover design

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Proceedings

3rd International Weed Conference

on

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ACKNOWLEDGEMENTS

The Publication Committee of the 3rd International Weed Conference is pleased to present the Proceedings containing the ABSTRACTS of keynote lecture, presidential lecture, plenary lectures, lead lectures, oral and poster presentations submitted by the Weed Scientists for presentation at 3rd International Weed Conference on *"Weed problems and management challenges: Future perspectives"* being organized at Anand Agriculture University, Anand, Gujarat, India from 20-23 December, 2022. A large number of papers were received covering a wide range of themes from all over India and a few from abroad. These papers were thoroughly reviewed by the members of the committee and others for both technical content and editorial quality.

The Publication Committee noted that though the papers, in general, covered the main theme of the Conference well, the number of papers on weed control in individual field crops far outnumber than those on other sub-themes. Further, papers on chemical weed control / herbicides usage are many but limited number of papers focused on other control measures and habitat management approaches in integrated cropping/farming systems. The papers on other relevant sub-themes, such as economics, ecology, weed utilization, weed science education, participatory research are also minimal. It was noted that large number of papers clearly highlighted the role of weed science in contribution to agricultural productivity.

We thank Dr. Sushilkumar, President, ISWS and Dr. J.S. Mishra, Secretary, ISWS and Organizing Secretary of this 3rd International Weed Conference for giving us this opportunity and providing their guidance and inputs for bringing out this proceeding. The Publication Committee thank each and every contributing Weed Scientist, who hail from India and different countries across the globe, for their sincere efforts in the preparation of the presentation to be made at the 3rd IWC and submitting the "Abstracts" of their Plenary/Lead/Invited oral - presentations/papers, in time for compilation in this publication. Thank you - all the contributing Weeds Scientists.

We appreciate the efforts made by Mr. Gyanendra Pratap Singh in processing, and formatting of articles, and helping immensely in bringing out the proceedings in a record time.

20 December, 2022

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PREFACE

Agricultural research and technologies played a key role in meeting the challenges of the past and helped the world in overcoming the challenges successfully, till to date. Agriculture has much greater role to play to face the current and future challenges of the world by providing food- and nutritional-security, in an ecologically and economically sustainable manner, to ever increasing global population which is expected to be around 9.9 billion by 2050. The food- and nutritional-security challenges of the world can be met by identifying the constraints and alleviating them in agri-food systems. Of the biological and physical constraints that need to be alleviated, weeds stand first since the initiation of agriculture by human being, as weeds are pioneers of secondary succession and compete with crops for the resources that both need for their successful growth and production, as both are plants with similar resources requirements.

Weeds importance in agriculture need not be explained as the farmers spend more time on weed management than any other cultural practices in developing countries and as farmers spray more herbicides than any other pesticides to manage other biological constraints, in developed countries. The losses caused by weeds were estimated to vary amongst countries and ecosystems depending on weeds associated, environment factors, management practices used and several other factors. For example, losses due to weeds were reported as AU$ 3.3 billion in Australia; US $ 11 billion for ten crops in India and US$1.14 billion in the United States for wheat crop alone. In addition to causing enormous crop yield losses, weeds reduce resources (land, water, nutrients, light, energy, labor) use efficiency and crop quality, serve as alternate hosts to several pests and diseases, cause health (skin and respiratory) problems to human beings, waste human energy and increase cultivation cost to manage them. Thus, in spite of sincere research and extension efforts across the globe and the adoption of weed management technologies by farmers, weeds continue to be major constraints in agri-food systems.

So far weed management efforts have been herbicide centric, in several of the countries across the globe as the herbicides are effective and economical. However, the over reliance on herbicides for weed control by farmers of the world, for a long period of time, has resulted in several adverse impacts including the selection of weeds with resistance to herbicides, in many countries. The discovery of new herbicides has declined significantly over the past few decades. Thus, the time has come to move away from the mono-disciplinary perspective at targeting weeds to multidisciplinary and multifaceted technological solutions to serve as a component of overall technological solutions to improve weed management in particular and agricultural production in general for achieving ever increasing food- and nutrition-security challenges.

Indian Society of Weed Science (ISWS) is thus organizing, at this critical time, the "3rd International Weed Conference (3rd IWC)" with the theme on "Weed problems and management challenges: Future perspectives". The reputed Weed Scientists from India and across the globe are invited to present their research findings, to have fruitful discussions amongst them and chalk out future course of action involving collaborative efforts among like-minded scientists on aspects of Weed Science and management to meet the current and future challenges posed by weeds in different ecosystems.

On the special occasion of the 3rd IWC being conducted at Anand Agriculture University, Anand, Gujarat, India from 20-23 December, 2022, a series of publications were brought out on the status of weed science research in the world in general and India in particular. This publication comprises of the abstracts of one keynote presentations, nine plenary presentations, seventeen lead presentations, fifteen invited oral presentations, one hundred and five voluntary oral presentations and two hundred and eight poster presentations to be made by respective papers presenting Weed Scientists at the 3rd IWC.

The members of the publication committee that has undertaken the voluminous task of compiling, editing and presenting these articles in a systematic manner under the Chairmanship of Dr A.N. Rao with Dr. Ashok Yadav as Convener; Dr. R.P. Dubey & Dr. Shobha Sondhia as Co-Chairmen and Drs Guriqbal Singh, Gulshan Mahajan, C.M. Parihar, Simerjeet Kaur, Manoj K. Singh, Malay K. Bhowmick, Puja Ray and Yogita Gharde as members. It is hoped that this publication will be useful to scientists, teachers, students, administrators and policy makers who are concerned with weed management in respective countries. Certain of the papers are included as Review and Research articles in Indian Journal of Weed Science (IJWS), 2022, Volume 54, Number 4. It is expected that others papers will be published in the forthcoming issues of IJWS.

We are hearty thankful to the following companies for extending financial help to society for organizing the 3rd International Weed Conference: ADAMA India Pvt Ltd, Corteva Agriscience, Bayer Crop Science Limited, IRRI, AG Bio System *etc.*

The financial assistance received from Research and Development Fund of National Bank for Agriculture and Rural Development (NABARD) towards this publication is gratefully acknowledged.

20 December, 2022

Sushilkumar
Convenor, 3rd IWC

J.S. Mishra
Organizing Secretary, 3rd IWC

and

Publication Committee

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Keynote lecture

Ensuring food security at global level: Role of weed science

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The current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100. Global food demand in terms of cereal equivalent is projected to be around 10,094 million tons in 2030 and 14,886 million tons in 2050. India and China are capturing large share of global food demand. To feed this population, global food production need to be increased by 70-100%. Despite reduction in the number and prevalence of undernourishment in recent decades, almost 8.9% of the global human population (690 million people) is still undernourished. To address the food security issue globally, a sustainable transformation of food and agricultural systems is required at all levels. To meet the increasing food security demands, reducing the existing large crops yield gaps is one of the appropriate approaches. Weeds are the major biotic constraints to agricultural production besides adversely affecting the agrobiodiversity, environment and human & animal health. Worldwide weeds caused the highest potential loss (34%) followed by insects (18%) and pathogens (16%). In India, total actual economic loss of about USD 11 billion has been estimated due to weeds alone in 10 major crops. Weed management is therefore much essential for agricultural production to meet future food requirements. In view of the emerging challenges in agriculture due to extreme climate events, declining water availability, energy crisis, labour shortage, global trade, herbicide resistance in weeds, adverse impact of herbicides on the quality of crop produce, environment and human health, *etc*., development of efficient weed management technologies incorporating the interaction of environmental, economic and societal dimensions of agro-ecosystems is vital for increasing productivity, sustainability and farmer's income. Developing scientific solutions for real weed problems needs intensive research in basic science. In the future, genetic manipulation such as RNAi technology, plant genome editing, nanotechnologies, microbial and bioherbicide products, robotics and drones, which are still in their research infancy, will add new tools in weed management.

Bioavailability of allelochemicals in soil environment under climate change: Challenges and perspectives

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Weed management is an important component in sustainable agriculture. The current agriculture is changing with climate change. Allelopathy has been recognized as a component tool for weed management over the years. The allelopathic ideas have been used in various facets of allelopathic implications. Some of these include use of cover crops, use of plant residues, plant extracts, crop cultivars and others. And it is being challenged under climate changes such as atmospheric CO_2, temperature rise, patterns of rainfall and others.

The relevance of allelopathy has been highly discussed due to the lack of phytotoxic concentrations of allelochemicals under field conditions. Crop residues from existing crop or rotational crops can provide selective weed suppression through their physical presence on the soil surface and/or through the release of allelochemicals. *Brassica nigra, Avena fatua, Fagopyrum esculentum, Secale cereale, Sorghum bicolor, Triticum aestivum* and other cover crops have been used in weed management on a limited basis. Some of the allelochemicals such as DIBOA, DIBOA-glycoside, dhurrin, isoflavonoids, isothiocyanate, juglone, momilactone, scopoletin, and sorgoleone have been reported to play a role in weed management under field conditions. The living and dynamic soil system influences the fate and functions of allelochemical activity. The bioavailability of allelochemicals in the soil is dependent on soil processes such as adsorption, leaching and degradations by abiotic and biotic factors. These processes and other related soil conditions are greatly influenced by many underlined climatic variables.

Future allelopathic research should be focused on identification of promising allelochemicals, persistence and availability of allelochemicals in soil environment. The bioavailability of allelochemicals under field conditions with climate changes such as rising atmospheric CO_2, rising temperature and intensity and periodicity of rainfall must be understood for promoting their effective role in weed management. Currently, we face challenges and opportunities in using allelopathy as a component of weed management strategies in today's agricultural production systems.

Plenary lecture 2

Allelopathy as a sustainable alternative in ecologically-based weed management systems

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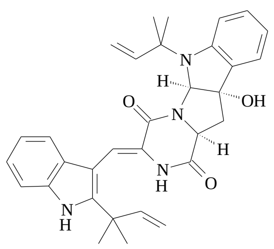
Plant allelopathy refers to the release of chemicals from plants or microorganisms into the environment which may have direct or indirect, beneficial or harmful effects on other plants or microorganisms. Screening of allelopathic plants by specific bioassay methods such as “Sandwich method, Plant Box method and Dish pack method”, about 4,000 plants were evaluated and cover crops with allelopathic activity were selected.

Allelochemicals working on the agricultural field were separated and identified by a new concept named “Total activity”. More than 20 chemicals were identified and some new chemicals were patented.

The traditional cover plants that show allelopathic activity are useful for weed management. Velvet bean (*Mucuna pruriens* var. *utilis*) originated in Indian continent and hairy vetch (*Vicia villosa*) originally from Mediterranean region were the two best allelopathic cover crops. I recommended these cover crops for Japanese farmers.

Hairy vetch is the most promising allelopathic crop and it is now an important component of sustainable organic agriculture as cover crop in orchards, vegetables and rice fields. Hairy vetch contains allelochemicals that selectively inhibit weeds and can thus be used in ecologically based weed management systems as it has the potentiality to inhibit field weeds. Cyanamide was identified as allelochemical from hairy vetch by total activity method. Recently we have identified new allelochemical “okaramines” as a product of *Penicillium* sp. hvef18 strain living as endophyte. Okaramines have potent insecticidal and fungicidal activity, but have promotive activity for many crops. By application of hvef18, yield of 20 crops were increased significantly.

Velvet bean is not well distributed in Japanese farmland as cover crop, but L-DOPA, an amino acid, identified by us as allelochemical, is an important precursor for dopamine, an important neurotransmitter in human brain, this plant is now gradually distributing as bean with medicinal value.



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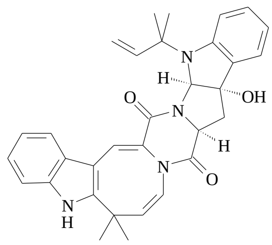

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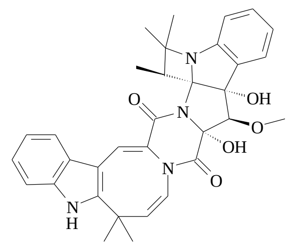

Okaramine B

Weed problems and management challenges: Future perspectives

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Identifying current and emerging research priorities in weed management is important to increase the productivity, bridge yield gap, increase resource use efficiency and feedback to breeding and policy decisions. Herbicide use increases by increase in population of a single most important weed and a few other annual weeds like *Phalaris minor* in wheat and *Echinochloa* sp. in rice. The chemical weed control became a necessity in late 1970s. Herbicides were introduced in 1979-80, weed flora diversified in favour of complex weeds species in late 1980s and then again in favour of *P. minor* in early 1990s. Resistance has evolved in *P. minor* against isoproturon and as a result, it has emerged as a single major weed species limiting wheat productivity in the Northwestern plains of India. In areas where the farmers started using graminicides like clodinafop and fenoxaprop the broad-leaved weed flora particularly *Rumex* spp. has increased. Here again resistance became an issue which is not as bad a cross resistance in *P. minor*. For several weed species, diversification between weeds and within weeds go hand in hand. In high yielding districts of rice crop, *Echinochloa crus-galli* is getting more prevalent, and *E. colona* is predominant in relatively low rice yielding districts. Similarly, *E. glabrescens* became more common and most troublesome weed with still higher yield levels in Punjab and Haryana. Yield levels in rice and wheat created selective pressure between weeds and within weeds.

In low yielding ecologies of Bihar, and eastern UP in rice-wheat cropping system, most ecologies in Odisha, Jharkhand, and Chhattisgarh and even in high yielding districts of Andhra Pradesh, *Cynadon dactylon* is amongst five most troublesome weeds. Fallow period in rice-fallow system and pulses in rice -pulse system helps creating a selective pressure of such weeds even under high crop yield scenarios. Agronomic practices that help increase the yield generated selection pressure for diversification between weeds, but monoculture and herbicide use generated selection pressure within one weed. Putting all this together would mean that we should monitor the shifts in weed flora at regular intervals. Same type of monitoring is applicable to herbicide use patterns, dose response equations especially in case of mixture and weed seed bank recruitment, herbicide application spraying techniques including herbicide application sensors embedded in drones and especially against new herbicides with single mode of action and against herbicide resistant crops.

The important areas which need focused attention include;

(i) Diagnosis of problem with what is already known and what needs to be determined. Spatial characterization of weed complex can help to explain the shift in weed flora.

(ii) Assessment of weed problems in long-term trials and their validation from the survey of weed flora under different situations.

(iii) Diagnostic monitoring of farmers' fields to provide hypotheses for testing the effects of cropping patterns, crop management techniques and herbicides on weed flora shift.

(iv) On-farm experiments to identify weed carryover between rice-fallow and rice-rice and rice-pulses cropping system.

Plenary lecture 4

Current herbicide development scenario: Need to launch reduced risk herbicides

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Corteva R&D is built on strong pipelines for seed, crop protection (CP) and digital built on short term and long-term value for farmers. Based on farmers demands and market signals, we apply a variety of technologies to make solutions which meet farmer needs and consumer preferences while protecting the environment and our resources. We use a rapid, flexible approach to discovery phase exploration of new chemical space. Computational chemists work closely with data scientists and synthetic chemists. We incorporate principles of sustainable chemistry and an understanding of sustainable building blocks into the design of new products, to develop the improved chemistries that have been a hallmark of our leading position as a provider of green solutions. With our approach and commitment to sustainability, companies like Corteva are coming up with new technologies that are safer, and will make farming more sustainable for generations to come.

Corteva has won 6 US Environmental Protection Agency (EPA)/American Chemical Society (ACS) Green Chemistry awards for our products, more than all other companies in our industry combined. We take a multi-pronged approach to R&D that combines innovative technologies in discovery and formulation to produce innovative reduced risk products that help farmers face challenges in the field while protecting the environment and our resources. Several government agencies that apply a fast-track regulatory approval process for low-risk products such as the US EPA has shared some data on the benefits of such a program to society and the environment. In Brazil, several decrees allow products with low toxicity profiles to be prioritized by three different agencies involved in the registration process: MAPA, ANVISA and IBAMA. With these provisions in the government regulations, we were able to receive prioritization for Rinskor registration, which accelerated access to farmers in Brazil to these products. This type of program also benefits the relevant government agencies, because it reduces their cost for reviews and provides the Government to newer and safer technologies for farmers. Corteva R&D efforts are also involved in improving the environmental and toxicological profile for older herbicides. Corteva is introducing a novel choline salt formulation of 2,4-D as Colex D that allows broadacre growers with proximity to 2,4-D sensitive crops, to access the robust weed control of 2,4-D in fallow with reduced risk of off-target damage. When used in accordance with the label directions, and following industry spraying guidelines, the built in Drift Reduction Technology (DRT), near-zero volatility and ultra-low odour means Colex-D is a 2,4-D that growers can apply with confidence.

In summary, R&D-based agriculture companies like Corteva continues to innovate to meet the demands of consumers, farmers, and the environment. These products can only be accessed by farmers with a policy environment that is science-based, risk-based, and encourages innovations.

Increasing problems of alien invasive weeds in the world: Management challenges and future perspectives

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The planet's temperature has risen by 0.5ºC since 1900 and will continue to increase at a faster rate. Because of change in land use pattern, the terrestrial biosphere of 21st century would probably be further impoverished in species richness. The biosphere will be generally more weedy. Altered precipitation, evaporation and temperature patterns due to climate change have resulted in weed flora shifts in northern coastal districts of Tamil Nâdu state, India. In particular, there has been a preponderance of invasive alien species such as *Leptochloa chinensis* and *Marsilea quadrifolia* in wetlands, *Trianthema portulacastrum* in uplands and *Eichhornia crassipes* in aquatic systems. Alteration in the precipitation and evaporation pattern coupled with frequent inundation and drought, increasing temperature regimes and sea-level rises that are regarded as consequences of global warming, would alter the nature of vegetation and agriculture in Asia. Increasing temperature regimes are observed to favour invasive potential of alien weeds in monsoon Asia. Under upland conditions, increasing temperature above 35ºC favoured the germination and establishment of *T. portulacastrum*, an invasive weed originated in Tropical Africa. Germination of noxious carrot grass *Parthenium hysterophorus* L. is observed to be triggered by a combination of higher temperature and moderate available soil moisture. Similarly, the rate of increase in root biomass of invasive alien weed *Prosopis juliflora* under increasing temperatures is observed to be higher, increasing its persistence potential and invasive behaviour. Research undertaken at Annamalai University in India is providing certain alternative solutions to manage these problematic weeds. Innovative use of fish culture and poultry rearing in rice fields was shown to compliment weed control through 400 on-farm experiments, with biomass reductions of invasive alien species ranging from 31-38%, in these districts. Similarly, using goats for off-season grazing reduced the biomass of weeds in upland crops. For example, biomass of the dominant *T. portulacastrum* declined by 23-29% in 500 on-farm participatory experiments. The invasive weed *E. crassipes* in aquatic systems was controlled in seasonal waterbodies within a season, by innovative and integrated use of insect agent (*Neochetina eichhorniae*) and plant product of *Coleus amboinicus* Utility modes for consuming the extensive biomass of *E. crassipes* have also been explored. Results indicate that tempo mediated extraction of Nanofibers offers an innovative tag of utility for management of this weed.

The role of changing climate in triggering the invasive behaviour of certain weed species resulting in a shift in the floristic composition of weeds is becoming obvious. Such a scenario warrants the need for multiple options to address a particular weed problem rather than relying upon unified approach. Accordingly, exploring the feasibility of engaging a systems approach of integrated farming, indigenous knowledge base and weed utility offers good weed solutions that reinforces sustainability.

Weed biology: An important science to develop effective weed management strategies

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The world's current population is about 8 billion and it is expected to be increased by 1 billion in the next 10 years. To feed this population, food production needs to be increased significantly. Several abiotic (e.g., drought, flood, heat, etc.) and biotic (e.g., insects, diseases, weeds, etc.) factors affect the productivity of crops. Among biotic factors, weeds are the most important constraint to crop production throughout the world. They cause a huge yield loss in different crops and cost growers a significant amount of money. Recently, based on data collected from farm trials on 10 major crops in 18 states, it was reported that weeds cause annual crop loss of $11 billion in India. Herbicides are widely used to control weeds; however, there are concerns over the evolution of resistance in weeds, limited availability of herbicides with new modes of action, and environmental pollution. Globally, more than 500 unique cases of herbicide-resistant weeds have been reported. In India, herbicide-resistant populations of *Phalaris minor*, *Rumex dentatus*, and *Cyperus difformis* have been reported. Recent reports on health concerns over the use of glyphosate have resulted in the ban of this most effective herbicide in some regions. These issues have challenged weed scientists around the world to develop ecologically-based weed management programs that rely less on herbicides. However, to develop such programs, detailed knowledge of weed biology and ecology is a prerequisite.

Weed biology is a broad topic and it includes aspects, such as seed ecology, weed emergence patterns, weed phenology, phenotypic plasticity, fitness penalty, and genetic diversity. Seed germination is affected by several environmental factors, such as temperature, light, water stress, seed burial depth, crop residue retention, and flooding depth. Knowledge of weed seed germination responses can help develop ecologically-based weed management programs by either suppressing germination or encouraging germination at times when weeds can easily be controlled. Similarly, knowledge of weed seedlings emergence patterns helps in deciding herbicide applications. Weed phenology is the study of the timing of weed growth stages in response to environmental factors. Knowledge of phenology is critical to understand weed growth, weed seed production, weed biomass, and the level of potential competition with various crops. The heritable genetic variation within and among populations of a weed species is called genetic diversity. Information on genetic diversity helps in understanding the ability of a weed to adapt to different environments and the impact of herbicide selection on weed populations. For example, a species showing a high genetic variation would require a variety of control measures and constant changes in management practices to counter adaptation in weed populations.

It must be understood that weed biology studies do not create new management products (e.g., herbicides). These studies provide a concept for weed management, which weed experts need to use in making informed decisions in the selection of weed control tactics for the industry. Weeds will keep adapting to different management practices. Therefore, we need to be proactive and understand their biology before they become very problematic. Just relying on one tool for their management will not be enough. Based on weed biology knowledge, diversified weed management programs need to be developed.

Non-GM HT rice is now in India: How to make it successful

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India recently released two HT (herbicide-tolerant) rice varieties that are tolerant to herbicide imazethapyr developed using the non-GM (genetically modified) approach. This is a historic development, in the backdrop of the stalemate and indecisiveness that is still continuing with respect to the promotion of GM HT technology in the country. Indian Government is yet to give approval for the cultivation of GM HT mustard and GM HT maize and cotton, despite having cleared all the regulatory requirements, mainly due to the pressure exerted by the GM activists.

HT rice varieties released, have been developed through mutation breeding techniques using the rice lines resistant to imidazoline herbicides. The varieties, *Pusa Basmati 1979* and *Pusa Basmati 1985,* developed by the ICAR- Indian Agricultural research Institute (IARI), New Delhi contain a mutated acetolactate synthase (ALS) gene making it possible for farmers to spray imazethapyr, a broad-spectrum herbicide, to control weeds. As the new HT varieties have been developed through mutation breeding and not by genetic modification, they will not be subjected to long and arduous regulatory procedures required for GM crops before their commercialization.

The technology of developing HT crops through non-GM approach is not new. The rice varieties resistant to imidazoline herbicides, popularly known as IR- Rice and Clearfield^R rice were first developed at LSU Ag Center of Louisiana State University (LSU) in the USA during 2002. Since then, under license with LSU, BASF – the agrochemical giant has been promoting the technology in different countries. Clearfield rice varieties have been in cultivation for a long time in the USA and in many countries in central and south America and Asia. The technology was quicky adopted by the farmers in regions where weedy rice (*Oryza sativa f. spontanea* or *O. sativa* complex) was the main problem. It offered excellent control of weedy rice, which is otherwise difficult to control. The weedy rice is a very competitive weed reducing the rice yield by up to 70%. None of the rice herbicides normally used in rice has any effect on weedy rice. The imidazolinone (IMI) herbicide component of the Clearfield® Production System (CPS) rice package provided excellent control of weedy rice and was largely responsible for significant increases in grain yield of rice across several countries. The success however, was short lived as continuous cultivation of Clearfield rice soon led to the evolution of resistant populations of weedy rice. The over-dependence on this technology alone and farmers' ignorance about the appropriate use of IMI herbicides were the key factors for this situation. The reduced the efficacy of IMI herbicides on weedy rice, ultimately nullified the benefits of the technology in affected fields and a few countries stopping the cultivation of Clearfield rice. Although rice is predominantly self-pollinating, interbreeding within and among rice species is possible. Besides geneflow, the mutations at the site of action in the weedy rice itself, also contributed to the resistance development. IMI herbicides inhibit plant growth by interfering with acetolactate synthase (ALS), a key enzyme in the pathway of biosynthesis of the branched-chain amino acids isoleucine, leucine, and valine. The ALS enzyme is more prone to mutations and continuous exposure to IMI herbicides may have also accentuated evolution of resistant weedy rice populations. As per International database of herbicide resistant weeds, the highest number of resistant weeds (at 171 weed species) are associated with the use of ALS inhibitors (https://www.weedscience.org/). The resistance to imazethapyr alone was reported in 42 weed species.

Anticipating the problem of HR weedy rice, the Clearfield® rice technology was introduced with a well drafted Stewardship guidelines, that included (1) planting of rice for not more than two consecutive seasons, (2) using certified seed, and (3) spraying the registered IMI herbicide at the specified rate and timing. The non-compliance or incomplete compliance of these guidelines is the most likely explanation for the failure of the technology.

There are a number of lessons to be leant from the experiences in other countries, while adopting the HT rice technology in India. The new varieties *Pusa Basmati 1984* and *Pusa Basmati 1984* that have been approved for commercial cultivation have great potential and likely to become popular with farmers, particularly in north west part of India. As these varieties are from a public sector organization, farmers will be free to plant them with or without the application of imazethapyr. However, in areas where weedy rice is a problem the technology is expected to make an immediate impact. As rice is planted under diverse agroclimatic conditions, the trait however, need to be introgressed into local varieties for wider applicability and larger benefit, particularly in areas where weedy rice is a major problem.

Minimizing the evolution of HR weedy rice populations is critical and challenging in sustaining the technology. In India it will be far more difficult to achieve this as rice monoculture is widely practiced with 2-3 rice plantings per year in many regions. With labour and energy cost increasing, the area under direct- seeded rice (DSR) is likely to go up in the future, which will have a significant impact on weed management. DSR is likely to present a more diversified, complex and competitive weed flora including the dominance of weedy rice. The buildup of volunteer rice and the risk of outcrossing with weedy rice are expected to be several times higher than what was observed in the North America or in regions where diversified cropping system is practiced. No technology is unlikely to succeed if practiced alone. The HT rice technology needs to be integrated suitably with other methods of weed management to make it more sustainable. It must be ensured that a long-term plan is in place with appropriate stewardship guidelines, institutional collaboration and oversight to make the technology successful. Agricultural being a state subject, the State Agricultural Universities will have a greater role to play in taking the technology forward. Creating awareness and educating the farmers in the nuances of the technology will be critical.

The objective of this paper is to sensitize stakeholders in India about the HT rice technology, analyze the global experience and stimulate/encourage discussion in developing a road map to make HT rice technology successful.

Plenary lecture 8

Do we see the end of chemical weed control soon?

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On an average loss caused by weeds far overweigh other pests, though the adverse effect varies with pests, crops, location, and weather. Data suggest that crop protection is more effective in cash crops (53-68%) over food crops (43-50%). In general yield increase by managing insect-pests and diseases account for 32 and 39%, respectively compared to 74% due to weed management. Herbicides have long been the jewel in the crown of weed management system, but their continuous use has resulted in the evolution of 266 herbicide resistant weed species (530 unique cases) spread in 71 countries infesting 95 crops including 35 cases (5 weed species) in wheat in N.W. India. This does not bode well for a developing country which is already predicted to suffer most from ensuing global warming, water shortage, soil sickness and farm fragmentation. There is trickling effect in finding new sites of action of herbicides that are less prone to evolution of resistance in weed species. In India, most of the recommended herbicides have failed to control all the resistant populations of *Phalaris minor* in wheat which bring us back to basics when farmers started mechanical weeding with no chemical option. The situation is more complex with five resistant weed species in wheat and commencement in other crops and herbicides, making weed control costly, less effective, and challenging. To a considerable extent, global warming and optimum moisture at spraying is affecting herbicide efficacy mediated by differential uptake/translocation and enhanced degradation. This situation requires to look out of the box solution as there were no herbicides before the 1940' and weeds were effectively managed. Herbicide resistant crops (HRC) even with stack genes will be vulnerable in a decade or so to resistance in weed species after their introduction; though CRISPR-Cas9 is also being hailed as breakthrough to develop HRC, but their acceptance in all crops, cost and success rate is questionable. An integrated approach using innovative agronomic practices that does not allow the dominance of a single weed species, its introduction/ spread to new areas and suppression by competitive crop varieties reinforced by manipulating seed rate, fertilizers, planting time and methods, irrigation methods/timing, crop diversification/rotation and avoiding seed rain can help in the long run for efficient weed management. One optimistic technology is robotics that can detect and destroy weeds; however, the cost and technological adoption with Indian farmers is questionable. It is more effective in wide row planted crops, though slow and with lower cost-benefit ratio as of today but has the potential to replace chemical weed control and is the best solution in organic farming. The autonomous and robust robots have the future to eliminate the need of herbicides in the next decade or two with consistent improvement, though currently restricted to high value crops in small areas but offers futuristic efficient weed management technology. Holistic interactions are needed today through chemical and non-chemical approaches to lower the losses caused by weeds, but robotic weed control is challenging and thrilling to replace herbicides in the future.

Plenary lecture 9

Current status of biological control of weeds and future perspectives

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The biological control of invasive alien plants species (weeds) has had a long and successful record dating back to the late 1800s when the first introductions of cochineal insects were made to target cacti. There have been 1555 intentional releases of 468 biological control agent species, used against 175 species of target weeds in 48 plant families, in 90 countries, until 2018. Although the USA, Australia, South Africa, Canada and New Zealand have been the most active countries, the greatest need for the weeds biological control development and implementation is in resource poor countries. The increasingly discerning public, greater human health awareness, greater environmental awareness and the rapid evolution of resistance of weeds to herbicides are making weeds biological control more relevant now than ever before. The initiatives such as the European Union Green Deal which aims to halve pesticide use by 2030 also augurs well for a global increased reliance on biological control.

In terms of the science of weed biological control, public and government perceptions of the safety of the science have largely been allayed, and pre-release testing ensures that a risk assessment framework can be used to make decisions regarding releases. However, biological control practitioners will always be questioned regarding the safety of this weed management method and must be prepared to offer rational, science-based and balanced clarifications. Post biocontrol agent release evaluation is still neglected and there is the need to improve projects assessment processes. Funding agencies of biological control efforts, users of the technologies and society on the whole need to be better informed as to the return on investment of the biological control. Thus, there needs to be more research into how advantageously biological control has alleviated the ecological and economic impacts caused by the weeds, and ultimately reduced the reliance on herbicides usage.

In an increasing complex society, there will be an increasing number of regulations regarding the collection, movement and use of genetic material. It is encouraging to see how the biological control community has not dismissed this added administrative burden, but rather engaged with it. This philosophy must continue.

The driving forces in weed management are vast and varied, and they continue to i and change. Biological control is in an ideal position to be the primary player in integrated weed management systems provided it meets the challenges that are currently faced and those it might face, in future.

Lead lecture 1

Application of digital technologies for weed detection and precision management

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Weed management remains a major challenge in broad-acre crop production. Herbicide-resistant weeds are particularly an emerging issue throughout the world, and there is a need for developing novel tools and technologies to support integrated weed management. Site-specific weed management can be an effective strategy for improving management outcomes, enhancing resource use efficiency, and achieving long-term sustainability. Artificial intelligence (AI)/machine learning (ML) tools have great potential in this regard, yet they have been less explored for agricultural applications, especially for weed management. Various deep convolutional neural network models have been evaluated for their effectiveness in detecting and distinguishing various weed and crop species under field conditions. Synthetic images have been utilized to improve model training and prediction accuracies. Advancements have also been made on the use of drones and ground vehicles for site-specific treatment of weeds with herbicides and other management tools. The use of precision technologies is expected to facilitate effective management of resistant weeds through smart diversification of strategies. Current advancements, knowledge gaps, and future line of research will be discussed.

Lead lecture 2

Real-time monitoring and assessment of floating aquatic weeds using multi-modal data acquisition system

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Rapid and unplanned growth of human population and simultaneous increase of anthropogenic water pollution has resulted in ubiquitous presence of eutrophicated water bodies in the tropical and sub-tropical parts of the world. In the frost-free part of the world water hyacinth [*Eichhornia crassipes* (Mart.) Solms)] infestation is very common in such eutrophicated water bodies. Adverse effect of water hyacinth infestation on agriculture, aquaculture, transportation and quality of life of the population living in the vicinity of these infested water bodies is well documented. Attempt to eradicate water hyacinth infestation by adopting mechanical, chemical or biological techniques have thus far yielded modest success at the field-scale. In absence of suitable valorization potential physical or mechanical removal of the mat which often require unskilled and/or skilled manual labour is becoming increasingly expensive. Use of herbicides to control the spread of water hyacinth in a water body is expensive and often gets restricted considering its potential adverse environmental impact. Biological control measures which often uses natural predators of water hyacinth such as weevil *Neochetina eichhorniae* though are ecofriendly has long gestation period thus far seen limited effectivity. Fast growth rate and long viability of its seed, deposited in the benthic sludge of the infested water bodies, makes its complete eradication difficult to achieve. In water bodies suffering from chronic water hyacinth infestation, water hyacinth mats represent perennial supply of nutrient rich biomass. Recently, mining of these nutrient rich aquatic weeds and valorization of the harvested biomass has emerged as a more sustainable way of weed management. The periodic harvesting and utilization of the harvested water hyacinth biomass for making handicrafts, paper plates, fish feed or compost is possible. However, development of a business model would require accurate assessment of biomass yield potential for a given infested lake or canal. Assessment of biomass harvesting potential *i.e.,* how many tons of biomass can be harvested during which period of the year for a given aquatic weed species at a given agro-climatic region would help to optimize the scale of valorization initiatives such as a rural enterprise making handbags using suitably dried water hyacinth biomass. Understanding the impact of water quality on the growth rate of aquatic weeds and vice versa is important to forecast which part of a vast lake spread over several hundred square kilometers are more likely to see reemergence of an aquatic weed. At present, the freely available satellite data acquired by Sentinel-1 or Sentinel 2 satellites have limited capacity to differentiate between water hyacinth and other floating, submerged or semi-submerged aquatic vegetation.

The work presented here is an attempt to provide real-time assessment of the size a water hyacinth mat. Multi-spectral drone acquired high resolution data has been used to decipher satellite acquired images of the same water hyacinth mats using transfer learning algorithms. Simultaneous assessment of water quality parameters has also been done to develop artificial intelligence-based techniques to forecast temporal and spatial distribution of water hyacinth mat in a large lake (>4 ha).

Lead lecture 3

Weed management in conservation agriculture: lessons learnt and ways forward

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A concept for resource-saving agricultural crop production, conservation agriculture (CA) strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. It promotes above- and below-ground natural and biological processes towards efficient use of resources. CA is a fastest growing technology adopted globally on 205 million ha area in 102 countries. It involves simultaneous application of three interlinked inter-associative principles such as continuous no or minimal mechanical soil disturbance by direct planting, permanent vegetative soil cover or mulch to protect the soil surface, and diversification of cropping systems by including legumes. These principles highly influence weed seed bank, weed spread and dynamics. Thus, a conservation agriculture system requires a total paradigm shift from conventional agriculture with regard to management of crops, soil, water, nutrients, weeds, and farm machinery. CA changes crop microclimate that selectively favours weed germination/emergence, leads to changes in weed species composition triggering weed dynamics and causes a paradigm shift in weed flora over time. Usually, weed diversity gets narrowed down to a few weeds or single weed dominance over time. Continuous residue cover, minimal soil disturbance, and diversified cropping system under CA are responsible for the changes in weed flora. Some weeds are favoured by the changes in microclimate and emerge profusely than others under continuous zero tillage (ZT) system. This results in weeds shifting towards perennials under CA systems, which are better adopted under less-disturbed soils. Perennial dicots weeds such as *Polygonum plebejum* (Indian knotweed) and *Alternanthera philoxeroides (*Alligator weed) have been observed in continuously CA plots under rice-wheat system, and *Sonchus arvensis* (Sow thistle) under CA-based rice-mustard system. Annual weed shifts towards small-seeded ones is generally observed under CA. But, annual grassy weed *Phalaris minor* is reduced considerably under ZT compared to conventional tillage (CT) system. CA is a herbicide-driven technology, and herbicides are key to efficient weed management under CA. The chemistry of herbicide and the art of application of herbicide play role on the overall efficacy of herbicide. The “5R Stewardship” (right choice, source, dose, time and method of application) should be followed for harnessing higher weed control efficacy with no crop phytotoxicity and little or no implication to environment. Several selective pre-emergence and post-emergence herbicides, some of which are low-dose and high-potency molecules are now available to effectively manage weeds in major field crops like rice, wheat, soybean, cotton, sugarcane, pulses and oilseeds under CA. Use of higher dose of herbicide and high-volume rate at pre-emergence sprays, granular herbicide formulation for soil application, broad-spectrum and non-selective herbicide during off-season to control perennial weeds, and post-emergence herbicides are preferred than pre-emergence under CA. Most herbicides are not effective against perennial weeds, which reproduce, mainly, through vegetative means. Perennial monocots like *Cyperus rotundus* (Purple nutsedge), *Saccharum spontaneum* (Tiger grass), *Cynodon dactylon* (Bermuda grass) and *Sorghum halepense* (Johnson grass) reproduce from underground vegetative structures, tubers, rhizomes, stolon, corms etc. The infestation of *Cyperus esculentus* increased tremendously in different CA-based systems after 8 years. *Euphorbia microphylla* after wheat harvest also became dominant in CA-based rice-wheat system. There is an urgency of developing selective post-emergence perennial weed killer herbicides for crop diversification and advocation of dynamic herbicide recommendation/herbicide rotation under CA. Long-term effects of a given herbicide, impact on soil biota, pollution of water bodies, persistence in soil, resistance by certain weeds to a specific herbicide are of concern and needs continuous research. A dynamic integrated weed management (IWM) programme is essential involving tillage, residue, cover crops, intercrops and herbicides in CA system.

Can conservation agriculture practices help in managing the weed problems and future challenges?

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Weed issues in current agricultural production systems is characterized by persistence weeds due to monoculture, excessive tillage, use of seed admixture with weed seeds, weed shift, wide periodicity of weed germination/emergence and inappropriate selection and application of herbicides. Insufficient knowledge of weed biology and changes in weed flora, herbicide-resistant weeds, lack of comprehension of the impact of climate change on weeds and weed control, management of weeds in small farms, unavailability of labour and mechanical tools, shifts in weed flora and weeds that are resistant to herbicides are the real challenges of Indian weed research. In recent past, climate change has also shown tremendous effect on changing weed dynamics and level of weed infestation, hence needs fine tuning of crop-establishment system and weed control options for sustainable weed management. These issues should be addressed through proper natural resource management and agronomic interventions. The development of potential options for efficient weed management to enhance crop productivity and food security is the biggest opportunity as well as challenge for Indian weed scientist. Conservation Agriculture (CA) approaches are helpful in addressing these issues, as it provide opportunities to reduce the cost of production, save water and nutrients, increase yield, increase crop diversification, improve efficient use of resources and benefit the environment. Major problem of weeds associated with the CA based production system is due to less expertise / management skill in implementation of CA practices. Rational crop rotation is helpful in changing the cycle of the weed which ultimately reduces the weed infestation. Crop residue retention also alters the soil surface temperature and acts as a physical barrier for the weed seed germination, which ultimately help in minimizing weed infestation. There is a myth that weed problem is more under CA. In fact lower weed problem is being observed with long term CA-based crop management practices/sustainable intensification. Research has shown that zero tillage (ZT) combined with retention of crop residue (standing stubbles of 40 cm height) is a potential tool for effective weed management in rice –wheat (RW) cropping system in Eastern IGP. CA based practices *i.e.* permanent no-till residue managed beds and double no-till (ZT direct seeded rice- ZT wheat) reduced weed infestation in rice-based cropping systems due to less weed seed bank disturbance in soil and proper cover of soil by the residue. ZT DSR with anchored residue was found to be most effective in minimizing weed density, dry weight and nutrient depletion by weeds. Residue retention with *Trichoderma* application was proved more effective over the residue removal in minimizing the weed density and total dry weight in ZT wheat. Full CA based practice (ZT-DSR *fb* ZTW *fb* ZT Mungbean (*Vigna radiata*) residue retained all crops) was found significantly superior over conventional crop establishment method (PTR *fb* CTW) in reducing weed density by 42% in rice and 36% in wheat and enhancing system productivity by 12%. These results provide evidence that full CA practices with residue retention and sensible diversification can reduce weed problem, especially seasonal weeds and enhance crop productivity in long-run. CA-based practices along with need based stale seedbed techniques, sound crop establishment methods, crop & herbicide rotation and rational use of pre- and post-emergence herbicides can be potential solution for addressing the weed problem and future challenges like herbicide resistant sustainable weed management. Further CA practices will help in avoiding the occurrence of climate change due to lower fossil fuel consumption which indirectly results in lesser weed shift. In CA adopted fields greenhouse gas emission (particularly methane) is lesser which ultimately help in less climatic change. CA practices helps in climate mitigation on account of early maturity, terminal heat avoidance and moderating soil temperature which ultimately useful in enhancing productivity and avoiding weed resistance. Future weed management strategy should integrate sensible CA practices along with site-specific approaches through scientific and practical application of modeling and robots. Research for decision-support systems and site-specific conservation agriculture (sensible tillage, residue retention and diversification) based weed management techniques is the need of the hour.

Weed management in vegetable crops: Problems and perspectives

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India's diverse climate ensures the availability of all varieties of fresh vegetables. It ranks second in vegetable production in the world, after China. In India, vegetables are cultivated in 10.86 million hectares area with production of 200.45 million metric tons (NHB, 2021). According to FAO (2020), India is the largest producer of ginger and okra among vegetables and ranks second in the production of potatoes, onions, cauliflowers, brinjal, cabbages, *etc*. form all horticultural crops, vegetables contribution is highest (59-61%) in all respect. Looking to the nutritional readiness, it's become integral part of Indian dishes and ICMR recommended 300 g/person/day vegetables consumptions. Therefore, the vegetables require extra emphasis to improve production and productivity of it to feed the millions of human mouths. Most of the vegetables are slow growing during the initial stage of development, makes them more vulnerable to weed competition, which has a negative impact on the quantity as well as the quality parameters. Broadly, weed extract two times more N and Ca and 30 per cent more potassium than the crops. The growth of weeds in vegetable production systems is enhanced by soil disturbance, irrigation and the application of fertilizers. Weeds harbor many vegetable diseases, nematodes, mites and insects, especially aphids and thrips that transmit viruses. Weed pressure is generally higher when soil conditions are poor due to heavy cropping. Generally, one third periods of crop growing seasons is considered as critical crop-weed competition periods, where it is very much essential to remove / manage weeds by integrated approaches. Besides, weeds emerging after the critical weed-free period will not affect yield, but control efforts after the critical weed free period may make harvest more efficient, reduce weed seed bank and reduce weed problems in subsequent years. Weeds compete with crops for growth factors resulting into a maturity delay and yield reduction. The extent of yield losses depends on the type of weed flora, intensity and duration of weed competition and soil and climatic factors. The reduction in the economic yield of vegetables is reported upto 95 % (Okra 40 -80%, Potato 52%, Bottle gourd 40%, Onion 40 -80%, Cabbage 45 – 80%, Carrot 90%, Tomato 92-95%, Brinjal 30 -35%, Chilli 60 -70 %, Garlic 94.8%, Radish 86% *etc.*). besides, weeds increase the cost of growing vegetables, impact on farm management decisions such as timing of harvest and choice of herbicide options. Farmers usually have a various method for weed control and their choice of control measures is closely controlled by economics. Although, herbicides were introduced to horticultural crops in India in 1960, hand tools and animal drawn equipment still remain important methods of weed control in vegetable crops. Owing to high cost and non- availability of labour at proper time, aberrant weather and soil conditions, crop growth stage *etc*, become major limitation of physical / mechanical methods of weed management. Herbicidal weed management is a reliable and simple choice to manage this situation. However, dependence on herbicides alone for weed management is not encouraged due to environmental problems and resistance development in weeds. Therefore, a system that combines herbicides with cultivation and other good crop husbandry practices should be highlighted. It is a system approach to maintain the weed population below the economic threshold level by adopting all available means of weed management, includes cultural, mechanical, chemical, biological and biotechnological practices in a balanced way without any harmful effect on environment, besides, considerably reduced the weed seed bank.

Lead lecture 6

Herbicides residues in soil, water and plants: Mitigation challenges and perspectives

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The healthy, highly productive and innovative new herbicides are continually being discovered and moving into development to replace, or to complement the older herbicides. Nevertheless, due to the introduction of several of these crop protection chemicals human beings are getting exposed to their adverse impacts too. The common perception is when a compound persisted significantly beyond the life of the crop when it was applied it is considered as undesirable with a toxic tag even if the following crop was proved as tolerant. This is the point of interpretation and discussion in rightly answering the question of how to judge the importance of a residue and its levels. For most compounds it is possible to detect, and often measure quite accurately, quantities of herbicide residue levels which are with/without any biological consequences. The length of the time required to establish with some confidence that there are no effects however uncertain may require voluminous research data and information. It is much complex when we consider the total environment because of the number of biological systems that must be taken into account. In practice there are differences in the evaluation of the significance of the persistence of residues between the agricultural and environmental (plant/crop, soil and water) view point. The farmer needs precise and all critical information, preferably on field application basis without gaps.

No matter how detailed information is available on residue in the biological and environmental systems, accurate prediction in the field is impossible because of the variability that occurs from point to point. A good residue extraction method therefore will, by definition, should remove all the herbicide residues present in the soil that is not classified as 'bound'. But there is no easy way of knowing how much of the extractable residues are available and how much they got predicted and what are they. Irrespective of the hyphenated analytical tools currently in place the actual risk of residues in food, water, air, or other environmental constituents and answer for the absence of residues or the non-detectable, is still unresolved due to the limitations of the tools used or ambiguity on the actual non availability of residues. Many researchers have correlated the association between pesticide exposure and elevated rate of chronic diseases. Majority are the projections designed through hypothetical models due to the limited data at exposure under actual scenario.

In bringing down the persistence, the approaches currently in practice have significant lacunae. The deliberate attempt in accelerating decomposition of residues by artificial means, induction of organisms that may lead to rapid breakdown which are unintentionally too rapid are suffering from the affordability and ability in the field. It is possible in the laboratory to change degradation rates to some extent by adding nutrients etc., and adjusting the pH, but the effect of such manipulations is uncertain in field perspective due to their limited success. The future will remain on the success of establishing new tools with sites of specific action, natural products, use of transgenic herbicide tolerant crops and biological weed control. The selective and specific pesticide biomarker may perhaps be the parent itself, generic or specific metabolites, or the products formed due to the interaction between the chemical and target biomolecules can be precisely investigated in biological samples as an alternative tool in drawing the conclusions towards the mitigation of the residues.

Lead lecture 7

Botanical herbicides for eco-friendly weed management and sustainability of smallholder farming

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Weed management in current food production systems is largely facing ecological and economic challenges worldwide due to the human and environmental risks and hazards with the injudicious use of synthetic chemical herbicides. Botanical herbicides have long been acknowledged as attractive alternatives to the synthetic chemical herbicides for weed management in organic and natural farming food production systems, and even they can play a bigger role under smallholder farming systems in general since botanicals reputedly pose a little threat to the environment as well as human health. Identification, development, and use of novel, easily available, cost-effective, biodegradable, and environment-friendly plant-based herbicidal compounds is essential to combat the weed menace including the increasing rates of herbicide resistance in weeds. The body of scientific literature documenting the bio-efficacies of plant derivatives for weed management continues to expand. Although only a handful of botanicals based on plant essential oils are currently in use, they do not adequately reach the marketplace and are not even widely commercialized for weed management in the industrialized world. Exploring the easily available plant resources is the need of the day while advancing the science, technology, and innovation, and ensuring LEISA in agricultural production systems.

Field studies over the last two decades by using herbicides based on naturally occurring plant sources such as *Bambusa vulgaris* (root and leaf), *Calotropis procera* (young twigs), *Cucumis sativus* (matured plants), *Eucalyptus cameldulensis* (leaf), *Tectona grandis* (leaf), and young plants of *Parthenium hysterophorus*, *Bergia capensis*, *Ageratum conyziodes*, *Blumea lacera*, *Cyperus difformis*, *Echinochloa colona*, *Ocimum sanctum*, *Physalis minima*, and others as pre-emergence aplication (PE) in Annual planning of weed pest management (APWPM) on different agricultural crops revealed that there exist huge prospects and opportunities for commercial development and usage of newer botanical products towards promotion of Low External Input Sustainable Agriculture (LEISA) and organic agricultural practices in the context of climate change, human health, natural farming and sustainability issues. Using these plant-based natural products in place of costlier synthetic chemicals exhibits higher productivity of crops like greengram, blackgram, groundnut, onion, potato, rice, rapeseed-mustard, sesame, soybean, besides improving soil and plant health status, crop diversification opportunities, farmers' income and livelihood, and rural welfare while addressing the risks and concerns associated with the synthetic chemical inputs, and also the issues of untimely availability of costlier chemical inputs in the hands of smallholder resource-poor farmers.

Improvement in the scientific understanding on the mechanism and mode of action of allelochemicals in their allelopathic control of native weeds offers new prospects for rightly and timely use as pre-emergence the botanical products in crop protection. Agri-skill and entrepreneurship development and developing farmers' awareness on using more and more natural products in agriculture are some of the initiatives for sustainable organic and precision farming. Compared with other bio-control methods, the popularization and commercialization of botanical herbicides for weed management has been constrained by several factors. The botanicals show the inhibition and suppression of grassy weeds mostly. Hence, the botanical herbicides in judicious combination with other weed management tactics including mechanical weeding would be a potential tool to the combat weed menace in smallholder farming systems.

Weed Management in pulse crops: Challenges and opportunities

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Pulses have been an integral part of India agriculture since time immemorial. By virtue of their ability to fix atmospheric nitrogen and being rich in vegetable protein, pulses offer one of the viable options for crop diversification, nutritional security and agricultural sustainability. Developing countries contribute about 70-75% to the global pulses production. India has pride of being the world's largest producer of pulses contributing 27.69 mt to the global pulses basket. Weeds are the principal biotic constraints to crop production. Sometimes complete crop failure observed in pulses due to weeds. In addition to direct effect, weeds are acting as an alternate host for many diseases and insect-pest.

Diversity and intensity of weed infestation in pulses varies with the agro-ecological condition and cultural practices followed. Various types of weed flora including narrow-leaf (monocots, grasses), broad-leaved (dicots) and sedges are found in different pulse crops. The reduction in growth and yield depends on the kind of weed flora and their infestation in the field. Weeds compete with crop plants for sunlight, nutrient, soil moisture and space. The extent of crop–weed competition for these limited resources and reduction in crop yield are dependent on type and intensity of weed flora present in the field. There are several constraints in effective weed control in pulses. Some of these are: i) grown under rainfed with low inputs, ii) higher crop-weed competition, iii) toxicity of herbicides used in pulses to other crops in rotation, iv) limited availability of herbicides and v) shift in weed flora.

The main aim of effective weed management is to manage weeds in such a way that will encourage the growth of plants beneficial to our interests and will suppress the remaining unwanted plants (weeds). There are many approaches by which weeds can be effectively and economically managed in pulses and pulse based cropping system. Some of these approaches are preventing spread of weed seeds in new areas, following of crop rotation/ intercropping, soil solarisation, summer ploughing, mechanical method, allelochemical, chemical method (herbicides) and herbicide tolerant varieties. In a long-term study at Kanpur showed that inclusion of pulses can reduce the infestation of *Phalaris minor* and *Avena fatua* (wild oat) in winter crops. Crop like mungbean and urdbean which grow faster and can compete with the weeds very well should be included in the cropping systems. Soil solarization can minimize most of the annual and perennial weeds belonging to genera *Amaranthus, Anagallis, Avena, Chenopodium, Convolvulus, Digitaria, Eleusine, Fumaria, Lactuca, Phalaris, Portulaca, Solanum* and *Xanthium*. But, weed management using herbicide is gaining popularity in the recent past due to several reasons. The main reason is scarcity of labour for weeding on time. Presently many good post-emergence herbicides such as imazethapyr, topramezone, quizalofop-ethyl, clodinafop-propargyl + Na-acifluorfen *etc.* are available for effective weed control in pulses. A definite strategy needs to be followed in conservation agriculture (CA) for effective weed management and higher crop productivity. Good agronomic practices like proper sowing time, paired-rows planting, crop rotation, intercropping, cover crop, maintaining residue cover over soil and use of herbicides need to be incorporated to manage weeds effectively in CA.

Country needs 39 million tons of pulses to fulfill the demand of growing population by 2050. Hence, sustained efforts must be made to increase the productivity of pulses under different production systems by incorporating modern technologies for developing weed management strategies.

Weed management in smallholder rice production in Asia: Challenges and opportunities

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Rice is the staple cereal for more than half of the world population; therefore, it is the key crop for global and regional food and nutritional security. To meet the global rice demand, it is projected that an additional 96 million tons of milled rice will be needed by 2040. The challenge is to meet this target using fewer resources (land, water, labor, and chemicals) and with a lower environmental footprint while buffering the risks of climate variability to ensure food and nutritional security, and environmental sustainability. Reducing rice yield gaps caused by weeds could help in achieving this target. Weed management practices in rice in Asia are changing in response to rural drivers of agricultural change including emerging issues of labor and water scarcity, rising production costs, and climate change. Because of these drivers, farmers are shifting from most dominant rice cultivation method of puddled transplanted rice (PTR) to direct-seeded rice (DSR), flooded to alternate wetting and drying (AWD) water management system, and from hand-weeding to herbicide-based weed control. Weed management is the biggest constraint in the wide-scale adoption of these new systems (DSR and AWD) and several weed-related issues/ challenges have emerged including: i.) risks of higher yield losses due to higher weed infestation; ii.) evolution of weedy rice which poses a serious threat to DSR sustainability; iii.) shifts in weed flora towards difficult-to-control weeds; iv.) increased dependence on herbicides resulting in the evolution of herbicide-resistant weeds; and v.) weed management becoming more knowledge-intensive. Additionally, large knowledge and information gaps exist in farmers' current weed management practices. A huge opportunity exist to close yield and profitability gaps of smallholder rice farmers caused by sub-optimal weed control due to knowledge and research gaps by: i.) developing robust weed reconnaissance systems to monitor spatial distribution of troublesome weeds to guide weed management recommendations as per weed flora; ii.) characterize farmer's current weed management practices at scale for problem solving and early warning and to identify entry points to close knowledge gaps; iii.) developing and deploying flexible and cost-effective sustainable integrated weed management practices, and iv.) creating enabling environment for wide-scale adoption of sustainable weed management practices. Examples of these interventions will be presented.

Sustainability in rice ecosystem with direct-seeded rice and emerging opportunity of carbon farming

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Rice is a staple food for more than half of the world's population and is pre-dominantly grown as well as consumed in Asian countries. In India, it occupies area of 44.5 Mha, contributes 25% to global rice area and 21% to global rice production, thus its cultivation is significant for both food as well livelihood security of these farming communities. Conventionally, it's being grown as puddled transplanted rice (PTR), where seedlings are raised in nursery bed, and manually transplanted to the main field at optimal age under puddled conditions. Limited water availability for puddling, and labor shortage for transplanting, are the key drivers forcing the rice growers for alternative crop establishment methods. Besides this, high energy requirement and methane gas emission from PTR cultivation are the main threats to environment and resources. Direct-Seeded rice (DSR) has emerged as an alternative crop establishment method, where nursery raising and transplanting of seedlings are not required, and seeds are mechanically/manually sown directly in the main field. DSR offers multiple benefits *viz.* saving in irrigation water, reduction in labor requirement, reduced greenhouse gas emission, less cost of cultivation, and positive effect on the performance of succeeding crops. Since the water resources (both surface and underground) are shrinking rapidly and profit margins are decreasing in PTR, thereby switching to DSR is a viable and economic option. As a sustainable rice production approach, DSR has been gaining attention of the stakeholders and policy makers across the rice geographies.

Bayer CropScience, is a global leader in developing crop protection solutions, and climate-smart rice hybrids (*Arize*) which offers wider adaptability in wider geography with tolerance to biotic and abiotic stresses. On an average, Arize series hybrids offers 20 to 35% higher yields than conventional inbreds. Coupled with hybrid rice, DSR technology has immense potential to enhance rice productivity sustainably, which can provide additional income advantage for growers. Bayer's innovative crop protection portfolio including novel weed management tools, further provides safe and sustainable solutions to rice farmers for mitigating climate risks. As a global leader in agriculture, Bayer is committed towards sustainable agriculture, by reducing the greenhouse gas footprint of crop production where our products are used by 30 percent by 2030. Accordingly, in 2020, Bayer rolled out the "Sustainable Rice Project", in close collaboration with the national agricultural research and extension systems (NARES) partners in India. This project aims to encourage rice farmers to switch from transplanted rice to direct-seeded rice and adopting the alternate wetting and drying approach under irrigated PTR ecologies. This project further aims to strengthen the emerging voluntary market for carbon credits in India. Sustainable rice production system complemented with carbon credit market is one the emerging avenue for the rice community, which offers additional environmental services through carbon trading.

Pollen-mediated gene flow and transfer of herbicide-resistant alleles from herbicide-resistant to susceptible weeds

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Pollen-mediated gene flow (PMGF) refers to the transfer of genetic information (alleles) from one plant to another compatible plant. With the evolution of herbicide-resistant weeds, PMGF plays an important role in the transfer of resistance alleles from herbicide-resistant to susceptible weeds; however, little attention is given to this topic. The objective of this work was to review reproductive biology, PMGF studies, and interspecific hybridization, as well as potential for herbicide resistance alleles to transfer in the economically important broad-leaved and grass weeds common in corn-soybean cropping systems in the United States. The PMGF studies involving these species reveal that transfer of herbicide resistance alleles routinely occurs under field conditions and is influenced by several factors, such as reproductive biology, environment, and production practices. Interspecific hybridization studies within *Amaranthus* and *Ambrosia* species showed that herbicide resistance allele transfer is possible between species of the same genus but at relatively low levels. The widespread occurrence of herbicide-resistant weed populations and high genetic diversity is at least partly due to PMGF, particularly in dioecious species such as Palmer amaranth and waterhemp compared with monoecious species such as common lambsquarters and horseweed. Prolific pollen production in giant ragweed contributes to PMGF. Kochia, a wind-pollinated species can efficiently disseminate herbicide resistance alleles via both PMGF and tumbleweed seed dispersal, resulting in widespread occurrence of multiple herbicide-resistant kochia populations. Creeping bentgrass, a wind-pollinated turfgrass species, can efficiently disseminate herbicide resistance alleles via PMGF and movement of seeds and stolons. The genus *Agrostis* contains about 200 species, many of which are sexually compatible and produce naturally occurring hybrids and hybrids with species in the genus *Polypogon*. The self-incompatibility, extremely high outcrossing rate, and wind pollination in Italian ryegrass clearly point to PMGF as a major mechanism by which herbicide resistance alleles can spread across agricultural landscapes, resulting in abundant genetic variation within populations and low genetic differentiation among populations. Italian ryegrass can readily hybridize with perennial ryegrass and rigid ryegrass due to their similarity in chromosome numbers (2n = 14), resulting in interspecific gene exchange. Johnsongrass, barnyard grass, and wild oats are self-pollinated species, so the potential for PMGF is relatively low and limited to short distances; however, seeds can easily shatter upon maturity before crop harvest, leading to wider dispersal. The observations from this review verify that intra- and interspecific gene flow can occur and, even though at a low rate, could contribute to the rapid spread of herbicide resistance alleles. More research is needed to determine the role of PMGF in transferring multiple herbicide resistance alleles at the landscape level.

Pros and cons of herbicide tolerant crops in Indian agriculture

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Crops made tolerant to herbicides by biotechnology are being widely adopted in various parts of the world and several herbicide tolerant crops (HTCs) have become available in many countries for commercial cultivation. Results of field trials have been carried out evaluate and consolidate the agronomic advantages of herbicide tolerant transgenic cotton and maize have been consolidated and the pros and cons of herbicide tolerant crops are discussed in this paper. Herbicide tolerant stacked traits of maize and cotton have been evaluated under Bio-safety Research Level (BRL I) as confined field trials for its agronomic efficiency on weed control and enhanced crop productivity at Tamil Nadu Agricultural University (TNAU), Coimbatore and Punjab Agricultural University (PAU), Ludhiana for many years. In both crops, potassium salt formulation of glyphosate was sprayed at different doses (900, 1350, 1800, 2700, 3600 and 5400 g a.e./ha twice at 25 and 60 days after seeding (DAS) in cotton and 900,1800 and 3600 g a.e./ha at 25 DAS in maize). Evaluation was made on weed control efficiency, phyto-toxicity on crops, yield and economics and carryover effects on the succeeding crops. Application of glyphosate at 2700 g a.e/ha recorded lower weed density, biomass and higher weed control efficiency (WCE) in cotton. Post-emergence application (PoE) of glyphosate at 900, 1800 and 3600 g a.e/ha registered lower weed density, biomass and higher WCE in transgenic Hishell and 900 M Gold and in 30V92 and 30B11 corn hybrids. Post-emergence application of glyphosate in transgenic maize hybrids did not affect the germination per cent, vigour and yield of succeeding green gram in the transgenic maize trials and sunflower, soybean and pearl millet in cotton trials. Phytotoxicity symptoms were not observed in cotton with glyphosate at lower doses viz., 900, 1350, 1800 and 2700 g a.e/ha. Higher doses viz. 3600 and 5400 g a.e/ha were noticed with phytotoxicity symptoms at early stages of herbicide application. Glyphosate applied at 900, 1350, 1800 and 2700 g a.e/ha recorded more number of bacteria, fungi and actinomycetes compared to atrazine treatments. Higher grain yield was recorded with glyphosate at 900, 1800 and 3600 g a.e/ha PoE in Hishell and 900 M Gold transgenic hybrids and higher net return and benefit cost ratio was recorded in glyphosate at 1800 g a.e/ha in transgenic 900 M Gold in all the four seasons. Glyphosate at 900 and 1800 g a.e/ha PoE registered higher grain yield in transgenic 30V92 and 30B11 corn hybrids. In maize and cotton transgenic crops, post emergence weed management with glyphosate proved to be the better management option for the control of weeds.

Herbicide tolerant crops are strongly impacting weed management choices. In many crops their use will decrease the cost of effective weed management in the short to medium term. However, HTCs offer the farmers a powerful new tool that, if used wisely, can be incorporated into an integrated weed management strategy, to more economically and effectively manage weeds. In maize and cotton transgenic crops, post emergence weed management with glyphosate proved to be the better management option for the control of weeds.

People participatory model for value addition and utilization of invasive aquatic weeds, with special reference to water hyacinth

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Water hyacinth (*Eichhornia crassipes*) is the most troublesome weed in the world. Under favorable growth conditions, the weed will double within about a week's time and cover the entire surface of the water. This mat-forming nature degrades natural habitats in several ways and causes the greatest threat to biodiversity. The thick mats prevent the entry of sunlight and atmospheric oxygen from entering the water, thereby increasing the Biological Oxygen Demand (BOD). Disease spreading vector species of mosquitoes breed freely in the static waters enhancing the chances of mosquito borne diseases. The water quality loss makes it unsuitable for human use. Many reports suggest that the rate of emission of methane (a greenhouse gas) from weed infested water is more, thus contributing to global warming. Due to the infestation, normal day-to-day activities are severely impacted resulting in huge economic loss and hindrance to agriculture, fishing, inland navigation, clam collection, movement of harvested paddy and other produce. Since, water hyacinth infestation affects livelihood of thousands of people, not only in Kerala but also across India and other tropical and subtropical countries in the world, several attempts have been made to eradicate and control the weed through physical, chemical and biological means, without any success.

The only solution lies in the economic utilization of these plentiful "natural resources" by sustainable, simple, innovative and economically viable techniques - the concept of management through utilization or use to reduce. Our research at the Centre for Research on Aquatic Resources, S. D. College during the last twenty five years has been focused on developing strategies for the utilization of these weeds. We have developed an Integrated, Decentralized, People-participatory Model which requires low investment, is easy to adopt, environment friendly, sustainable and ensuring alternate livelihood to those who are living near the water ways, especially in the wake of climate change related issues and post-COVID economic crisis. The presentation will focus on our strategy on sustainable management of aquatic weeds in the light of our innovation and experience. Our initiatives on research and development, extension activities, conduct of awareness and training programs, translating the research into marketable value added products through Student Start-ups will be discussed. Results of the international, interdisciplinary, multi-institutional project on water hyacinth monitoring in India will also be presented.

Lead lecture 14

Biology and management of wild oat in Australia

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Wild oat *(Avena* spp.*)* is one of the most serious weeds in Australian winter season crops such as wheat, barley, chickpea, etc. *Avena. fatua* and *Avena ludoviciana* are the dominant species of wild oat in cropping regions of Australia and about 80% of wild oat populations in Australia contain both of these species. Although, *A. fatua* and *A. ludoviciana* are quite similar in morphological features, there are some variations during the reproductive growth stages which may be helpful to distinguish them from each other. The similarities and differences in the botanical features of wild oat species help to make effective management strategies. Propagation of wild oat can occur through seeds and its seed dispersal is mainly caused by agricultural machinery, use of the contaminated seeds and crop residues, etc. Seed recruitment of wild oat in the soil occurs through high seed production and the shattering ability of plants. Wild oat seeds have innate dormancy and the persistence of seeds in the shallow layer of soil could maintain the weed seed banks in the soil. A range of weed control or prevention methods have been identified for the management of wild oat species. Chemical weed control is generally considered the most important and cost-effective tool for the control of *Avena* spp. However, due to the over-reliance on chemical weed control strategies in Australian farming systems, wild oat has evolved resistance to many herbicides and continuous use of one herbicide has increased the resistance build-up in many populations on a large scale in Australia. Thus, among the major challenges to the sustainability of Australia's prevalent agricultural system, herbicide resistance in wild oat is the important one. Recently, the world's first case of glyphosate-resistant *A. fatua* and *A. ludoviciana* has been reported in Australia. This necessitates the rotational use of herbicides for sustainable wild oat control by selecting a diverse range of herbicides available that permits flexibility in choosing herbicides with different modes of action, acting at different stages of crop growth (pre-seeding, seeding, post-seeding, and late stem elongation). This strategy can provide cost-effective and sustainable control of wild oat. Non-chemical weed management practices, such as sanitation, crop residue burning, tillage operation, crop rotations, and improved crop competition approaches could reduce the infestation of wild oat. The recent incorporation of allelopathy and harvest weed seed control in management of wild oat also present further opportunities for optimal implementation in effective weed management. The adoption of any single technique cannot provide effective, sustainable, and season-long control of this weed as different species of wild oats vary in dormancy and growth habits. For sustainable control of wild oat, integrated strategies involving chemical and non-chemical tactics such as tillage, crop rotation, crop competition, seed rate or seeding density, manipulation in sowing time, harvest weed seed control, and allelopathic suppression, may prove useful. These integrated weed management strategies are also effective for managing and reducing the herbicide-resistant populations of wild oat. Knowledge regarding understanding of wild oat ecology could aid in strengthening integrated management of this weed.

Stealing the secretes of weeds: The stress tolerance mechanisms and their implication for climate resilient agriculture

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Weeds have typically been defined as ‘plants which are a nuisance’ or ‘a plant where we do not want it’. Weeds are generally believed to be harmful to crop production and human welfare. As humans decide what species are considered to be weeds, the effect of a weed is difficult to quantify. The benefits of weeds are less well understood than the adverse effects, and more challenging to quantify because they occur over a longer time scale. Weeds are an essential component of the agroecosystem and, therefore, are a part of biodiversity, and they have several potentialities which are often neglected. Weed ecology provides a basic understanding of the distribution and abundance of weeds in natural and managed systems. In the long term, it may change our attitudes and perceptions toward weeds and alter the way we manage them. Therefore, the question remained largely unanswered how these weeds are so abundant and prolific even under adverse climate conditions. In terms of competitive traits, a genotype may survive for years with a suite of traits, but if the environment changes drastically, the genotype may be quickly placed at a competitive disadvantage. Researchers are seeking new ideas and models to help us define, understand, and predict weed biology and likely societal impacts of unparalleled human-induced climatic uncertainty in the twenty-first century. Numerous studies also revealed that weeds produce a wide variety of ecotypes that can be fitted to various environments. Many weed species are extremophiles that can adapt to stressful conditions such as salinity, drought, extreme temperature, waterlogging, etc. As climate change is one of the serious threats to crop production worldwide, plant biologists are very keen on developing climate-resilient crop varieties. Preservation of crop diversity is necessary because each adaptation represents a different response to a range of abiotic and biotic stresses. A single variety over long periods will encounter environmental limitations that will result in yield loss. Therefore, having additional varieties of the same crop gives farmers a “tool” to begin to adapt to changing conditions. Because wild lines have so much genetic variability, adapting current crops to climatic extremes using the wild lines’ genetic material is an attractive possibility. Weeds are a naturally available (although unexplored) gene pool and can be used as a source of genetic material for traits like abiotic stress tolerance for crop plants. Competitiveness, ability to survive under adverse conditions and their coexistence with crop plants make weeds a potential source for trait-based gene(s) transfer into crop plants. Many weeds can change their morphology, physiology, and biochemistry to cope with the stresses. So, unrevealing the physiological and molecular mechanisms of stress tolerance in weeds may provide clues to tailor the traits and use them to develop tolerant crop plants. Several weed species are also good candidates for the phytoremediation of salt or metal-affected soils. Scientists are hoping to breed or genetically engineer genes from these weeds successfully into food crops. A coordinated endeavor in exploiting those potentialities may contribute to ensuring food security in the era of climate change and the fourth agricultural revolution.

Weed management in millets: Challenges and perspectives

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The term 'millet' refers to small seeded, coarse grain cereal crops grown for food and fodder purposes. They are grouped as major millets *i.e.,* sorghum (*Sorghum bicolor* L.), pearl millet (*Pennisetum glaucum* L.) and minor or small millets comprising finger millet (*Eleusine coracana* L. Gaertn.), barnyard millet (*Echinochloa frumentacea* L.), little millet (*Panicum sumatrense* Roth ex. Roem. and Schult.), foxtail millet (*Setaria italica* L.), kodo millet (*Paspalum scrobiculatum* L.) and proso millet (*Panicum miliaceum* L.). In India, during 2018-19, millets were cultivated on an area of 12.54 million hectares with a production of 13.71 million tons with an average yield of 1048 kg/ha. These crops are grown under rain-fed soils with limited input use. Hence, the productivity is quite low which needs to be increased through development of better genotypes and crop management practices. Weed infestation may reduce the yield of sorghum by15-83%, pearl millet by16-94%, finger millet by 55-61% and kodo millet by 46%, depending on severityof weed infestation. In central India, the yield loss due to weeds in finger millet was estimated to be 46.6 to 68.1%, in kodo millet 56.6 to 67.3%, in little millet 59.6% and in barnyard millet it was 63.5%. The potential benefits of improved technologies will not be realized until appropriate weed management practices are adopted in these crops.

Majority of the millets are grown in *Kharif* season; hence these crops are infested with abundant growth of weeds. Among weed management practices, cultural i.e., stale seedbed, intercropping and mechanical methods i.e., weeding by hand-operated tools and animal-drawn implements are being followed by the farmers. Very few selective herbicides are available for use in millet crops. In sorghum and pearl millet, atrazine, pendimethalin, metolachlor and 2, 4-D have been recommended. In minor millets, effective weed management and higher crop productivity could be obtained by pre-emergence application (PE) of pyrazosulfuron 20 g/ha or atrazine 500 g/ha or metribuzin 150 g/ha or oxyfluorfen 100 g/ha followed by 1 hand weeding 30 days after transplanting (DAT) or metsulfuron-methyl 4 g/ha at 20-25 DAT of the finger millet, barnyard millet and kodo millet crops. In transplanted kodo millet, pendimethalin 500 g/ha PE can also be safely used. Depending upon soil moisture, metribuzin, oxyfluorfen and atrazine may cause phyto-toxicity to the direct-sown crop but are safe when used in transplanted crops. Good agronomic practices like well levelled field, planting at recommended spacing, band placement of fertilizers in crop rows help in reducing weed infestation.

In recent years, owing to their high nutritional value, awareness to millets as nutri-cereals has increased and they are in high demand again. Millet crops are best suited for crop diversification, under organic/natural farming and as climate resilient crops. Good crop management practices including effective weed management are the key to obtain higher yields. Development of weed competitive varieties can help in reducing the weed pressure during the early stages of crop growth. Since, options for selective broad-spectrum herbicides for these crops are lacking, research efforts need to be augmented to find out effective pre- and post-emergence herbicides for direct sown, as well as transplanted crops. Effective management strategy for the control of *Striga* – a parasitic weed in sorghum needs to be developed. Awareness and promotion towards cultivation of millet crops, especially minor millets, under organic/natural farming systems ably supported by non-chemical weed management practices is very much required.

Lead lecture 17

Need of South Asian regional network for invasive alien species management

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In an era of Anthropocene, biological invasion by alien species is considered as a dominant driver of global biodiversity decline and agriculture production loss with its impacts across all levels of biological organization (individual to ecosystem/landscape) and geographic scales (local to global). The invasive alien species (IAS) interact with other drivers of global environmental changes such as land use and climate changes, which makes biological invasion a complex environmental problem. Therefore, it requires multiple, collaborative scientific and management approaches to fully understand the patterns and processes of biological invasions and their interactive processes to identify and prioritize appropriate management responses. As biological invasions operate much beyond the political boundaries of countries, creating a network among various stakeholders at regional level to exchange data and knowledge, and collaborate in research and innovation, is crucial in developing regional strategy for the effective management of the IAS. While such regional networks and coordinated strategies are already operational in Europe and Americas, such network for IAS still does not exist in South Asia – a region inhabited by one fourth of the global human population, and characterized by high and unique biodiversity and a high and rising threats of IAS to agriculture and biodiversity. The eight countries of this region (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) share similar socio-cultural, climatic and environmental features which provide opportunities for collective actions to tackle common regional problems, including biological invasions. We call for establishing a South Asian Regional Network for Invasive Alien Species (SARNIAS) through participation of broader stakeholders including researchers, practitioners, and policy makers from universities, research institutions, government agencies, and national/international non-government organizations as well as students, citizen scientists, and representatives of indigenous people and local communities. The establishment of the SARNIAS will have following immediate benefits: i.) understanding of the regional patterns of biological invasions, ii.) early detection of IAS in the member states (and also at subnational level), iii.) up-scaling and out-scaling successful management practices across the regions, iv.) development of regionally coherent national strategy by member states for the IAS management, and v.) development of regional strategy of IAS management to complement the national strategies. The long-term benefits of the SARNIAS will include: i.) effective prevention and control of IAS, ii.) increased regional collaboration for research, iii.) reduced regional discrepancies of data availability in the global database, and iv.) improved science diplomacy.

Plant water extracts for organic weed management in groundnut

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Groundnut (*Arachis hypogaea* L.) is grown under tropical climate with hot and humid weather and hence confronted by repeated flushes of various grasses and broad-leaved weeds. Though, groundnut is a hardy crop, it is highly susceptible to weed preponderance due to small canopy and slow initial growth. Weed control with herbicides is expensive and pose detrimental effect on the environment. The toxic herbicides are polluting the surface and ground water for livestock as well as human beings and their residues released from the plants as well as from the soil, move into the nutrition cycle and ultimately become perilous for descendants. Thus, in recent years, research attention is now being focused on reducing the dependence upon synthetic herbicides and finding alternative strategies for weed management in general and in particular to organic and sustainable agricultural systems. Unlike synthetic herbicides, allelopathic compounds which are produced naturally in the plants used directly as herbicides. In this context, the field experiment was conducted to study the performance of different plant water extracts *viz.*, sorghum, sunflower, parthenium, lantana and purplenut sedge each 15 L/ha applied at 15 and 30 DAS, paddy straw mulch 5 t/ha, pre-emergence application (PE) of pendimethalin 1000 g/ha followed by (*fb*) HW and post-emergence application (PoE) of imazethapyr 75g/ha in a randomized block design during *rabi* 2017-18 in groundnut. During *kharif* 2017, allelopathic crop and weed plants were harvested at flowering and then shade dried followed by chopped with power operated fodder chaff cutter into 2 cm pieces, separately. The chopped plant material was soaked in distilled water for 24 hours at room temperature of 21^0C at a ratio of 1:10 (w/v) and the same was filtered through 10 and 60 mesh sieves. These plant water extracts separately boiled at 100^0 C to concentrate upto 20 times. The groundnut variety '*Dharani*' was sown with a spacing of 22.5 x 10 cm. The required quantities of plant water extracts and herbicides were applied by using spray fluid of 500 L/ha with the help of knapsack sprayer.

The predominant weed species observed were: *Cyperus rotundus* (45%), *Digitaria sanguinalis*(15%), *Borreria hispida* (7%), *Digera arvensis* (6%), *Boerhavia erecta* (5%), *Cleome viscose* (3%), *Dactylactenium aegypticum* (4%), *Trichodesma indicum* (4%). Paddy straw mulch 5 t/ha proved to be best in controlling weeds and promoting yield components and yield of groundnut as well as realizing higher net returns followed by sunflower water extract spray 15 L/ha at 15 and 30 DAS. Paddy straw mulch might have released allelomones *viz., momilactone B, p- hydroxyl benzoic acid, vanillic acid, p- coumaric* and *ferulic acids* which were identified as natural herbicides to control weeds. The inhibitory effect of sunflower water extract on weed growth due to presence of higher concentrations of *annuinones A, B, annuolide E, leptocarpin, heliannuols, isochlorogenic acid* and *scopolin*, which are considered as natural herbicides. The performance of parthenium water extract and purple nutsedge water extracts was poor in controlling weeds and promoting yield of groundnut.The reduction in pod yield of groundnut due to unchecked weed growth was 52.53 and 37.18% compared to pendimethalin 1kg/ha PE *fb* HW at 30 DAS and paddy straw mulch 5 t/ha, respectively. The pendimethalin 1 kg/ha PE *fb* HW recorded significantly higher number of effective rhizobium nodules/plant whereas paddy straw mulch 5 t/ha recorded significantly higher count of soil microorganisms *viz.,* bacteria, fungi and actinomycetes at 40 DAS and at harvest.

Invited oral lecture 2

Efficacy of different weed management practices on weed control and yield of *Kharif* groundnut

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Groundnut (*Arachis hypogaea* L.)is an important oilseed crop in India which occupies first position in terms of area and second position in terms of production after soybean. It is highly susceptible to weed infestation because of its slow growth in the initial stages upto 40 days, short plant height and underground pod bearing habit. Groundnut- weeds comprise diverse plant species from grasses to broad-leaf weeds and sedges, and cause substantial yield losses (15-75%).Hence, there is need to focus attention on herbicide mixtures as an option to enhance the weed control efficiency andbroadening the spectrum of weed control.

This field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during the *Kharif* seasons of 2020-22. The soil of experimental field was clay loam in texture, slightly alkalinein reaction, medium in organic carbon, available nitrogen and phosphorus but high in potassium.The experiment consisted of twelve treatments *i.e*., pendimethalin + imazethapyr ready mix (RM) 750 g/ha pre-emergence(PE); oxyfluorfen 180 g/ha *fb* imazamox + imazethapyr (Pre-mix) 70 g/ha post-emergence (PoE); imazethapyr100g/ha PoE *fb* IC + HW at 40 DA; imazethapyr+ propaquizafop(RM) 125g/ha PoE; imazethapyr + propaquizafop(RM) 125 g/ha *fb* IC + HW at 40 DAS; imazethyr + imazamox (Pre-mix) 70 g/ha PoE; imazethyr + imazamax (Pre-mix) 70 g/ha PoE *fb* HW at 40 DAS; fluazifop-p-butyl + fomesafen (Pre-mix) 250 g/ha PoE; fluazifop-p-butyl + fomesafen (Pre-mix) 250g/ha PoE *fb* IC + HW at 40 DAS; IC *fb* HW at 20 and 40 DAS and Weedy Checkwhich were laid out in RBD and replicated thrice. The TAG37A variety was used for the study.

The experimental area was infested with *Echinochloa colona* (46.4%), *Dinebra retorflexa* (12.1%), *Commelina benghalensis* (8.4%) and *Dactyloctenium aegyptium* (8.7%) among the monocot weeds, whereas, *Digera arvensis* (8.8%), *Amaranthus viridis* (6.6%), and *Physillis minima* (9.1%) were dicot weeds. Data indicated that at 60 days after sowing (DAS), compared to weedy check (60.23g/m^2), significant reduction in total weed dry matter was observed by different weed control treatments. Application of Oxyfluorfen 180g/ha *fb* imazethapyr + imazamox ready-mix (RM) 70 g/ha brought greatest reduction in dry matter (91.8 per cent) in comparison to weedy check, which was found at par with pendimethalin + imazethapyr (RM) 750 g/ha PE and significantly superior over rest of the treatments. At 60 DAS, highest weed control efficiency(WCE) was observed by oxyfluorfen 180g/ha *fb* imazethapyr + imazamox (RM) 70 g/ha by 91.78 per cent. Application of Imazethapyr + propaquizafop(RM)125 g/ha PoE *fb* inter culture(IC) + hand weeding(HW) at 40 DAS produced significantly the highest mean pod yield of 1.79 t/ha and haulm yield of 3.76 t/ha. The next best treatments in this regard were imazethapyr + imazamox (RM) 70g/ha PoE *fb* HW at 40 DAS, and fluazifop-p-butyl + fomesafen (Pre-mix) 250 g/ha PoE *fb* IC + HW at 40 DAS. The maximum net return (Rs. 79172/ha) was realised by applying imazethapyr + propaquizafop(RM) *fb* IC + HW, which was 266 per cent higher over weedy check (Rs. 21547/ha). The economic analysis of treatments in term of BC ratio revealed that the highest BC ratio (2.9) was obtained by controlling the weeds through imazethapyr + propaquizafop(RM) *fb* IC + HW at 40 DAS. Therefore, from the study it can be concluded that for effective control of weeds in *Kharif* groundnut along with higher yield and economic return could be achieved by post-emergence application of imazethapyr + propaquizafop(RM)125 g/ha *fb* IC + HW at 40 DAS.

Long term effect of tillage and weed management on weed dynamics and productivity of yellow sarson and greengram under direct-seeded rice-yellow sarson-greengram cropping system

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Field experiment was conducted during the *Kharif, Rabi* and summer seasons of 2015-16 to 2019-20 at Agriculture Farm, Visva-Bharati, West Bengal to study the long-term effect of tillage and weed management practices on weed growth, crop productivity and economics of direct-seeded rice (DSR)-yellow sarson-greengram cropping system. The experiment was laid out in strip plot design with three replications. Four tillage practices comprising of conventional tillage (CT) (DSR) — CT (yellow sarson) — CT (greengram), CT (DSR) — Zero tillage (ZT) (yellow sarson) — ZT (greengram), ZT (DSR) — ZT (yellow sarson) — ZT (greengram), ZT + Residue (R) (DSR) — ZT + R (yellow sarson) — ZT + R (greengram) were allocated to the horizontal strip and three weed management practices *viz.* Recommended herbicides (RH) (pre-emergence application (PE) of pendimethalin at 1.0 kg/ha followed by (*fb*) post-emergence application (PoE) of bispyribac-Na at 25 g/ha in DSR, pendimethalin at 0.75 kg/ha PE each in yellow sarson and greengram), RH + manual weeding at 35 days after seeding (DAS) and unweeded control were assigned to the vertical strip. *Digitaria sanguinalis, Cynodon dactylon, Echinochloa colona, Ageratum conyzoides, Spilanthes calva, Cleome viscosa* and *Indigofera hirsuta* were predominant weeds in yellow sarson in all tillage practices. But *Gnaphalium purpureum* and *Solanum nigrum* were present only under CT. In greengram, *C. dactylon, I. hirsuta* and *S. calva* were dominant under ZT and conservation tillage. The weed density and biomass, crop growth and yield attributes, yield and economic returns in conservation tillage were comparable with CT for yellow sarson in initial year. While, in fifth year conservation tillage (zero tillage with residue retention) registered significantly higher growth and yield attributes and yield. In greengram, conservation tillage recorded significantly lower weed density and biomass and higher growth and yield attributes, yield and economic returns over other tillage systems even from the initial year itself. The conservation tillage recorded 76.76% higher yield of yellow sarson in fifth year and 76.9 and 83.79% increase in seed yield of greengram in first and fifth year, respectively as compared to CT. Recommended herbicides and hand weeding at 35 DAS registered significantly the lowest weed density and biomass and highest growth and yield attributes and economic returns of yellow sarson and greengram. Conservation tillage with recommended herbicide alone each in yellow sarson and greengram recorded lower weed density and biomass and higher growth parameters, yield attributes, yield and economic returns. Without any weed management the seed yield of yellow sarson under conservation tillage was as good as of conventional tillage with recommended herbicide in fifth year, whereas in greengram it was even significantly higher. Thus, conservation tillage with recommended herbicides and hand weeding at 35 DAS in direct-seeded rice, recommended herbicide alone each in yellow sarson and greengram may be advocated for effective weed management, higher productivity and profitability of yellow sarson and greengram in direct- seeded rice- yellow sarson- greengram cropping system in lateritic belt of West Bengal.

Pesticide residue analysis challenges: An overview

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These days, food is produced and distributed in a worldwide market, which has led to strict laws and control for the quality and safety of food. This is done in order to safeguard consumers' health and guarantee that commerce is conducted fairly. In spite of these efforts, accidents related to food safety nevertheless occur on occasionally. These incidents may be traced back to both microbiological and chemical contamination. Particular areas of concern include residues from pesticides and veterinary drugs, endocrine disruptors, food additives and packaging materials, environmental pollutants (such as dioxins and heavy metals), and contaminants of natural origin (such as mycotoxins and marine toxins). The accumulation of pesticides in environment is exacerbated by the intensive use of these chemicals in agricultural production. The major challenges in pesticide residue detection are growing target analyte list, increasingly complex matrices, and the need for low limits of detection. There exist several techniques for detection of pesticide residues in food matrices like gas chromatography, liquid chromatography, high-resolution accurate mass spectrometry spectrophotometry, nanotechnology based colorimetric techniques, and biosensors. Among these methods the most commonly employed techniques are chromatographic methods coupled with mass-spectrometry. Utilising and applying these methods in a wide range of food matrices, residues may be quantified at quantities as low as parts per billion and even lower. But due to the complexity of the food matrix, it is necessary to use techniques of analysis that have a high capacity for separation and identification. A costly but complete answer to the problem of analysing pesticides is comprehensive gas chromatography coupled with time-of-flight mass spectrometry (GC-TOFMS). In LC-MS/MS analysis of food for pesticide residue analysis, the most typical issues that arise are instances of compounds with low recovery, low sensitivity in one transition, common transition with matrix or other analytes, as well as effects from solvent and matrix. According to protocol SANCO/12571/2013, the following should be considered the minimum necessary for identification with MS/MS i.e., e" 2 product ions and ± 30 percent maximum relative tolerance for ion ratios. In spite of the fact that nanoparticles-based colorimetric approaches have an extremely great potential, there are still several hurdles that need to be overcome in order to compete with the efficiency of regular analytical methods. The greatest difficulties associated with colorimetric applications are on the sensitivity, selectivity, repeatability of the findings, reproducibility of results, and multiclass residue analysis due to the fact that colorimetric techniques based on nanoparticles do not have the capability of separation in comparison to traditional GC–MS and HPLC procedures. Hence the challenge is to find the optimal distribution of the targeted pesticide among the various methodologies in order to get the greatest overall performance possible for the analysis in terms of accuracy, precision, speed, and cost. Because of the wide variety of physicochemical characteristics, not all of the pesticides that are tested using a multi-class, multi-analyte approach will provide findings that are in accordance with the guidelines validated for the method or the requirements for analytical quality control. Testing for an extended list of pesticides at a detection threshold that is gradually lowered is required as a result of updated regulatory requirements.

Determination of ready-mix herbicides residue in soybean cultivated tropical Inceptisol

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Soybean is a dual-purpose rainy season crop cultivated globally in 91.29 million hectares with a production of 2.20 lakh metric tonnes. India is having soybean area of 9.52 million ha with production of 9.90 million tonnes and a productivity of 1040 kg/ha. Maximum yield reduction occurs by weeds and the chemical weed control is the only economical option with less input cost. Hence the development and evaluation of suitable combination of herbicides active ingredients to manage the complex weed flora for soybean production is being continuously undertaken. . The new ready mix herbicides combination consisting fomesafen 12% and quizalofop ethyl 3% SC was registered recently as early post-emergence for controlling the broad- and narrow-leaved weeds in soybean. Being new combination, their persistence in soybean cultivated tropical Inceptisols was investigated employing bioassay and HPLC to assess its safety and health risk to consumers at Eastern block Farm, TNAU, Tamil Nadu. The test ready mix (fomesafen 12% + quizalofop ethyl 3% SC) was applied at two doses, *viz.* 1250 mL/ha and 2500 mL/ha as early post emergence along with untreated control. Samples of soybean seed, haulm and field soil were collected at harvest and stored in dry ice pack for residue estimation. Extracted herbicides residue from different matrices was analyzed with HPLC equipped with Diode Array Detector (DAD). After the harvest of soybean, the plant bioassay experiment was conducted using the sensitive indicator plants viz., sunflower and pearl millet as the follow up crops after soybean.

HPLC analysis showed that the residue of both the herbicides, *viz.* fomesafen and quizalofop-ethyl were not detected in the soybean seed, oil, de-oil cake and field soil samples at the time of harvest irrespective of the applied rate**.** The detection limit of fomesafen and quizalofop ethyl was found to be 0.005 and 0.01 mg/kg which is well below the standard MRL for soybean (0.025 and 0.05 mg/kg, respectively). No residue was detected in the control samples. Bioassay using sunflower and pearl millet as test crops also did not showed significant variation with respect to the germination percent, plant height at 30, 60 and 90 DAS and indicated that there is no residual toxicity due to the application of ready mix formulation consisting of fomesafen 12% + quizalofop-ethyl 3% SC at both the doses on the succeeding crops. Carryover effect was also not observed with respect to dry matter production and the yield of bioassay crops.

It may be concluded that the early post-emergence application of fomesafen 12% + quizalofop ethyl 3% SC (ready-mix) at 1250 ml/ha could be used in soybean grown in tropical Inceptisols for effective control of broad weeds group without carryover or residual toxicity.

Invited oral lecture 6

Weed management in organic farming – A review

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The global food sector is under pressure to produce enough to nourish a projected global population of 11 billion by 2050. Thus, it is imperative to identify ways and means for accelerated sustainable crop production. For accelerated food production, the use of intensive inputs like fertilizer and pesticides is inevitable. But, the chemical fertilizers applied year after year in the same soil may degrades the health and quality of the soil, thereby causing soil contamination. Thus, climate and biodiversity are depleted by the currently followed crop production system. However, for having equivalent production with organic agriculture that produces lower yields, more land may be required, but additionalland availability is limited. . The greatest hurdle on the way of successful organic farming to fetch a higher economical return is the loss of yield due to heavy weed infestation and restriction of use of herbicide, as is in case of conventional farming. Weeds are the second most important factor limiting the yields of many crops, after nutrient management. Weeds are the plants which are known as growing out of place, undesirable and reduce crop yield by limiting supply of nutrient, light and moisture. The organic farming is growing of crops without use of synthetic nutrients as well as use of other pesticides. Organic farming has drawn attention to much elite society as organically produced products are considered to be more nutritious, flavored and almost free from hazardous chemicals which otherwise can pollute them if applied in soil as fertilizers or on plants as spray materials. The organic farming results a healthy soil contrast to non organic one where food crops are sprayed with extremely toxic chemical that kill everything other than crop itself. But once those organisms are killed off, they are replaced with synthetic fertilizers made up from more toxic chemicals which reduce the crop yields in years to come due to soil sickness and environmental pollution. Organic farming includes living organism that a plant needs to grow and make the soil nutrient rich. Considering the sustainable crop production from healthy soil and to meet the demand of burgeoning population the adoption of organic farming is essential. Thus, keeping in above facts, this review discussed about various methods of weed managements like providing selective advantage to crop plants to compete over weed growth and other non chemical methods of weed management for successful organic farming.

Herbicide mixtures in rice

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Use of two way or three-way herbicide mixtures with different modes of action is increasingly becoming a standard practice in modern weed management strategies of rice cultivation in order to provide immediate and long term benefits like effective weed control, increase in spectrum of weed control, reduce the danger of human toxicity, delay in evaluation of weed resistance to herbicides etc. However, there are some limitations like loss of selectivity, reduced weed control and sometimes incompatibility during tank mixing etc. Despite these limitations, the use of herbicide mixtures becoming more popular during recent times in rice cultivationmainly due to increased spectrum of weed control and availability of ready mixtures in the market. Herbicide mixtures are of two types *viz.*,1). premixed / ready made formulations made by commercial companies and 2) tank mixtures made by farmers before application with desired and recommended herbicides. In rice cultivation during the last four decades different herbicide mixtures have been widely used for effective weed management. Several commercial factory made premixes have been developed including benthiocarb+bensulfuron; propanil + butachlor + pendimethalin; propanil + 2,4-D; butachlor / benthiocarb / anilofos / oxadiazonetcin combination with 2,4-DEE which were made available to farmers in the early eighties and the recently available mixtures such as: penoxsulam + butachlor/rinskor/cyhalofop-butyl/ pendimethalin; pyrazosulfuron-ethyl + pendimethalin / pretilachlor / bispyribac sodium; pretilachlor + bensulfuron-ethyl, cyhalofop-butyl + rinskor; triafomen + ethoxysulfuron; metsulfuronmethyl + chlorimuron-ethyl *etc* . Besides these, farmers are using several tankmixes like fenoxaprop-ethyl + bispyribac sodium/ bentazone/ethoxy sulfuron / metsulfuron-methyl + chlorimuron-ethyl / 2,4-D sodium salt / 2,4-D amine salt; cyhalofop-butyl + ethoxy sulfuron / 2,4-D sodium salt, 2,4-D amine salt /metsulfuron-methyl + chlorimuron-ethyl *etc* depending upon their availability and local needs for effective weed control. Thus, in rice herbicide mixtures presently used are mostly are two-way combinations and some are three-way combinations also being used for effective weed control in different systems of paddy cultivation. All these mixtures are found to be effective and economical when compared to traditional hand weeding mostly because of increased cost of labour wages. The work done so far in India on herbicide mixtures is very limited. Hence, it is essentialfor the weed researchers to begin active work and identify proper herbicide mixtures for practical utility in rice cultivation. In this paper, use of premixes /tank mixes in rice cultivation besides some guide lines for developing and using herbicide mixtures in rice cultivation are discussed in detail.

Invited oral lecture 8

Crop diversification and residue mulching for weed management in rice-wheat cropping system

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Rice is mainly cultivated by transplanting method of rice establishment in India even in water limiting regions. However, due to growing concern about the negative impacts of transplanted rice on soil health and the environment, there is promotion of conservation agriculture (CA)-based rice-wheat establishment methods viz., direct- seeded rice, non-puddle/unpuddled transplanted rice, bed transplanted rice, strip-tilled rice, single pass shallow tilled rice and double transplanted rice followed by zero tilled, strip-tilled and bed planting of wheat. In all these methods of rice establishment methods, nature of weed infestation and the losses caused to crop yield are variable. Variable soil tillage creates different ecological conditions for rice as well as weed growth, which ultimately affect the losses caused due to weed interference. The rice wheat system based on CA based technology is dominated by a few crop associated weeds in these systems. Thus, the weed management techniques have to be customized depending on growing ecology, availability of herbicides, crop residue management, and crop diversification, appropriate uses of machines and labors.

CA principles envisage sensible crop rotation and need-based residue retention besides minimum soil disturbance. Herbicide use had been increasing in CA based cropping system because complexity of weed flora increases in CA based crop establishments. Inclusion of crops in sequential and intercropping has been found to reduce nutrient and water needs and the population of troublesome weeds to a considerable extent thereby reducing herbicide needs to a great extent. Rotating crops having divergent agronomic and biological requirements with distinct morphologies, growth habits, life cycles, differing cultural practices, and nutrient and water needs can all potentially affect the weed community and distribution. However, under the year round cultivation there may be shifts in weed flora composition due to various cultural practices being performed throughout the year. In Indo-Gangetic plains summer season is kept fallow due to the non-availability of irrigation water hindering crop diversification. In this season, a successful cover crop like green gram/ black gram/ground nut may be taken to add organic matter and additional income to farmers of this region. The cover crops like *Sesbania* spp. during summer fallow will aptly enhance nutrient availability and break the cycle of troublesome crop-associated weed species. Crop residue left over in the rice-wheat cropping system can be used as mulch to suppress weeds, especially rice straw (5-8 t/ha) under variable cropping geometry. However, the placement of rice straw mulch in intra-row and inter-row spaces is a practical problem. Rice straw mats of various lengths and breadth can be made for better placement as per the spacing of the crops. Crop diversification for weed management could be popularized by providing micro fertigation facilities in rice-wheat cropping systems, especially during summer and winter seasons to establish diversified crops.

Performance of weedy plants in decentralized constructed wetland systems and their potentialof post-harvest biomass utilization for bio-energy production

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Large volume of waste water around 72368 million liters per day (MLD) is generated in India out of which 72% (52138 MLD) remain untreated and merges in surface water bodies including rivers, lakes, and ponds causing deterioration of water quality. In this paper, performance of weeds grown in surface and sub-surface constructed wetlands developed for treatment of different types of waste waters including sewage, industrial, dairy and river water of India is reviewed.In various case studies on macrophyte based treatments, *Phragmites karka, Typha latifolia, Arundo donax, Vetiveria zizinoides, Canna indica*asemergent and*Eichhornia crassipes*, *Pistia stratiotes*as floating aquatic plants were largely used for water treatment in decentralized sub-surface and surface constructed wetlands (CW) respectively. These plants were found capable of decreasing various test indicators for water quality ex. electrical conductivity (EC), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates, phosphates, sulphates and heavy metals including cadmium, chromium, lead, nickel to the levels of FAO standards that allow further use for industrial, aquaculture, and irrigation purposes are highlighted.

As far as conversion of post- harvest biomass is concerned, *Eichhornia crassipes* grown in surface treatment system shown great potential in production of methane under anaerobic digestion condition. Biogas digesters if properly configured, use of biomass of *Eichhornia, Typha*, if integrated with animal manure, can produce up to 10%higher biogas than manure used alone. Besides biogas, having fast growth rate, ability to grow in different climatic conditions, salinity tolerant, drought resistant wetland plants such as *Arundo donax* and *Phragmites karka* shown potentialas an alternative candidates for second generation lingo-cellulolytic sources of ethanol production are discussed. In addition, development of products including briquettes, bricks, particle boards, baskets, hand paper as value added products are explored which can be feasible for adaptation of the green technology for decentralized water treatment in small peri-urban localities of India.

Performance of imazethapyr doses and sequences against weeds in imidazolinone-tolerant dry direct-seeded rice

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In north-western India, rice is generally grown by manual transplanting in puddle fields. This system is labour intensive and leads to land and resource degradation. Direct seeded rice (DSR) has emerged as an alternate method of rice establishment, which has caught the attention of stakeholders as resource conservation technology leading to saving of soil, water and other natural resources. Weeds are the major problem in DSR. There is quick and diversified shift in weed flora along with heavy and prolonged infestation of weeds in DSR, which are sometimes quite difficult to manage with herbicides. Effective and season long weed control is important for higher productivity of direct seeded rice. The recent developments in herbicide tolerant (HT) technology has opened a new window of weed management in dry direct seeded rice. So, field experiments were conducted with the objectives to optimise imazethapyr doses and its spray timing for season long control of diverse weed flora in imidazolinone-tolerant rice under dry direct seeded conditions and to assess the residual phyto-toxicity effects of imazethapyr and imazethapyr+ imazamox herbicides on succeeding *Rabi* crops during 2020-21 and 2021-22 at CCS Haryana Agricultural University Regional Research Station, Karnal, India.

Imazethapyr *fb* imazethapyr as early Post-emergence (EPoE) *fb* Post-emergence (PoE) significantly reduced the density and dry weight of *Echinochloa crus-galli*, *Dactyloctenium aegyptium and Leptochloa chinensis* as compared to alone application of imazethapyr (EPoE); and effects were more pronounced at higher doses during both the years. The sequential application of imazethapyr *fb* imazethapyr+ imazamox (100; 70 g/ha), imazethapyr *fb* imazethapyr (125; 125 or 100; 150 g/ha) proved to be the best treatment combinations in controlling weeds, providing the grain yields (6.53-6.74 t/ha) as good as weed free check (6.82 t/ha) during *Kharif* 2020. Similarly, significantly higher grain yields (5.88 and 5.89 t/ha) were recorded with imazethapyr *fb* imazethapyr as EPoE *fb* PoE (125 *fb* 125 and 100 *fb* 150 g/ha) than alone EPoE application (100-200 g/ha) of imazethapyr (1.77-2.34 t/ha) during *Kharif* 2021. PoE application of imazethapyr showed more promising results in reducing grassy weed infestation as compared to its application as PRE (pre-emergence) and EPoE in sequence with other herbicides. Whereas, alone application of imazethapyr+ imazamox either as PRE and EPoE showed poor results in controlling weeds, particularly *Echinochloa crus-galli*. Further, there was no residual phyto-toxicity of the imidazolinone herbicides applied in HT dry direct seeded rice on the succeeding crops (wheat, mustard, chickpea, lentil and maize) in *Rabi* season during both the years, indicating their safety in different DSR based cropping systems. Findings of this study will help in formulating strategies for effective weed management to achieve the target of risk-free DSR based systems.

Biology, invasiveness and management of *Panicum repens* Linn. (Family: Poaceae)

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There is no specific record of when *Panicum repens* (English: Creeping panicum; Couch panicum; Panic rampant) was introduced in India. However, the plant is cultivated as soil binder in some parts of the country including Gujarat. In Assam, the plant is becoming a troublesome weed in recent decade. During the last few years, the plant is becoming rather aggressive and invasive both in cropped and non-cropped situations. *Panicum repens* is a perennial weed but its main growth period is the summer season. It blooms almost round the year. However, its peak blooming time is from May to October. *P. repens* is a rhizomatous, creeping perennial herb, rooting at the base. It grows around 30-90 cm tall. Inflorescence is an open panicle which is 6-20 cm long and branches are ascending; spikeletes are 3 mm long, acute and gaping at the tip. Fruits are glossy caryopsis, white in colour. Rhizome extension and fragmentation is the principal means of propagation of *P. repens*. Through vegetative growth each small fragments of *P. repens* present in the soil can give rise to dense stands. Also, the rhizome fragments buried deep into the soil up to 40-50 cm can give rise to new shoots. Within a very short period it can produce a monoculture colony by displacing herbaceous vegetation both by allelopathic potentiality and high competitive ability.*P. repens* can overcome long dry period. Simultaneously, it can survive and grow well in half merged condition in standing water even for a couple of months. *P. repens* can grow in a variety of soils; from sandy to heavy clay; however sandy loam soil is seen to be more suitable. The weed is rather aggressive in upland situations of low elevations, rather than in hills and aquatic situations. Tillage only encourages its growth. Surveillance study revealed that though *P. repens* appears as one of the most problematic weed of upland crops, it is equally problematic in transplanted rice in certain areas.

The biology of the plant was studied under different doses and methods of application of glyphosate comparing with undisturbed and untreated population stand. To record the biological changes, 50 cm square quadrat was used. Digging uniformly from 50 cm cuboids, soil was collected from each plot and plant organs (viz. rhizomes, suckers, etc.) were separated carefully for laboratory study. Amongst the treatments applied, the lowest biomass of total rhizomes and plant growth rate was recorded with glyphosate in two spits 0.75 kg/ha at 15 days interval along with 2% jaggery (tank mixed), which was at par with glyphosate 1 kg/ha + 2% jaggery. Both the treatments have also reduced the shoot-rhizome ratio.Complete control of *P. repens* with the doses of glyphosate tested during the experimentation was not recorded up to seven and half months after application of the herbicide. However, the results proved that sequential application of glyphosate was more effective than single application and lower doses of glyphosate were rather effective than higher concentration.

Study on emergence pattern of *Physalis minima* L. under different tillage systems

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Study on weed biology with regard to the effect of burial depth of weed seeds on seedling emergence resulted from conventional tillage revealed that seedlings of *Physalis minima* have emerged within 28 days from the seeds vertically distributed throughout the soil profile up to 3 cm depth. 100% emergence was recorded from 1 and 2 cm depth at 18th and 20th day, respectively and 64 and 9% emergence from 0 and 3 cm soil depth, respectively at 28th day. Seeds at 3 cm soil depth have undergone enforced dormancy and turning the soil at 87th day resulted in additional 51% emergence altogether 59% emergence up to 134th day. Wide variation on seedling emergence of *Physalis minima* was recorded when fruits were embedded within the soil or present on surface soil representing the situation like zero tillage. The study has been conducted on 5 different fruits (completely matured/ dark brown, matured/brown, partially matured/brownish green, fade green and deep green colour fruits) with different stages of maturity embedded within the soil. First emergence of seedling was recorded from fade green fruit at 27th day with 25.2% total emergence in 4 flushes (22.1, 0.6, 0.6 and 1.8%). First emergence from matured/ brown colour fruit was recorded at 33rd day with 82.8% total emergence in 4 flushes (31.3, 26.6, 9.8 and 15.3%). First emergence from completely matured/dark brown colour fruit was recorded at 42nd day with 68.7% total emergence in 4 flushes (19, 40, 7.4 and 1.8%). First emergence from deep green colour fruit was recorded at 55th day with 25.2% total emergence in 3 flushes (19.6, 2.5 and 3.1%). First emergence of weed seedlings from partially matured/ brownish green colour fruit was recorded at 56th day and it registered maximum value of total emergence 89.6% in 4 flushes (38.7, 39.3, 2.5 and 9.2%). Fruits having equal maturity only present on the surface soil revealed wide variation of seedling emergence and total emergence of seedlings. Fruit 1 recorded early emergence at 60th days, whereas fruit 2, 3, 4 and 5 recorder first emergence of seedling at 74th, 93rd, 101th and 107th day, respectively. Fruit 1 recorded maximum 87.7% total emergence of seedling in 5 flushes (15.3, 1.2, 34.4, 26.4 and 10.4%), whereas fruit 2 registered 72.4% total mergence in 4 flushes (14.7, 19.6, 28.2 and 9.8%), fruit 3 recorded 76.7% total emergence in 4 flushes (3.1, 25, 53.4 and 17.8%), fruit 4 registered 12.9% total emergence in 3 flushes (3.7, 6.1 and 3.1%) and fruit 5 recorded 46.6% total emergence in 3 flushes (10.4, 30.7 and 5.5%). Data were recorded up to 205 days. This study revealed wide variation on seedling emergence of *Physalis minima* when fruits were subjected to different tillage systems.

Weed control efficacy of herbicide mixtures on major weed flora of cotton in Cauvery Command Area of Karnataka

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Cotton (*Gossypium hirsutum* L.) is the most preferred natural fibre and contributes to one-third of the total fibre traded on a global scale. China, India, USA, Pakistan, Brazil, Uzbekistan and Australia are the major producers of cotton. Weeds in cotton production zones and their management is a major crop production challenge across the world. Poor weed management in cotton can lead to a significant yield reduction of 10 to 90% depending on weed management practices. . Rapidly emerging herbicide-resistant weeds due to inappropriate use of single herbicide further adds to the complexity of cotton weed management. A major change that occurred in the cotton farming is the rapid adoption of application of herbicide mixtures which are having different mode of action.

A field experiment was conducted during *Kharif* season of 2019 and 2020 at the College of Agriculture, V. C. Farm, Mandya to evaluate the efficacy of herbicide mixtures on control of weeds in cotton under Cauvery Command Area of Karnataka. The farm is geographically situated between 11^0 30' to 13^0 05' N latitude and 76^0 05 to 77^0 45' East longitude with an altitude of 697 meters above MSL. The soil of experimental site is red sandy loam within low in N (289 kg/ha), medium in P (42 kg/ha) and K (185 kg/ha). The treatments consisted of directed application of post-emergence herbicide, *viz*. glufosinate ammonium 12.8% + metolachlor 30% EW @ 2500, 3300 and 4100 ml/ha, glufosinate ammonium 13.5% SL @ 3000 ml/ha, paraquat dichloride 24% SL @ 2000 ml/ha and pre emergence application of metolachlor 50% EC @ 200 ml/ha. These treatments were compared with weedy check and hand weeding twice at 20 and 40 days after seeding (DAS) checks. These treatments were replicated thrice in a Complete Randomized Block Design.

The major weeds associated with cotton were: *Echinochloa colonum, Digitaria sanguinalis, Cynodon dactylon, Dactyloctenium aegyptium, Panicum repens,* among the grasses; *Parthenium hysterophorus, Potulaca oleracea, Commelina benghalensis, Trianthema portulacastrum, Convolvulus arvensis, Euphorbia hirta, Corchorus trilocularis, Mollugo stricta, Phyllanthus niruri, Stachytarpheta indica* and *Leucas aspera* among the broad-leaved weeds and *Cyperus rotundus* among the sedges.

The post- emergence application (PoE) of glufosinate ammonium 12.8% + metolachlor 30% EW @ 4100 ml/ha was effective in controlling all types of weeds and recorded significantly lower total weed density (3.65/m^2) and biomass (2.71 g/m^2) at 15 days after application of herbicide and recorded 97.76% weed control efficiency. As a result of effective weed control, the same treatment recorded significantly higher seed cotton yield (22.17 q/ha). However, it was at par with glufosinate ammonium 12.8% + metolachlor 30% EW 3300 ml/ha PoE. The uncontrolled weed growth throughout the cropping season reduced the seed cotton yield by 53%. It was concluded that post-emergence directed application of glufosinate ammonium 12.8% + metolachlor 30% EW 3300 ml/ha is an economically viable and profitable option to control the weeds in cotton.

Invited oral lecture 14

Aquatic weed mediated bioremediation of contaminants of environmental concern using a circular bioeconomy

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Abiotic stress is related to environmental factors such as salinity, temperature, acidity, alkalinity/sodicity, nutrient deficiency, chemical pollution, and poor water quality, whereas biotic stress is caused by living organisms such as weeds, pests and pathogens. Among edaphic stresses, the release of contaminants of emerging concern (CECs) including PBTs, POPs, EDCs, PPCPs, and PhACs from processing industries, pharmaceuticals, personal care, and anthropogenic sources adversely affect the aquatic environment, crops, animals, fisheries, and human health worldwide, due to their toxicity, persistence, and bioaccumulative nature.

Alleviation of abiotic stress caused by CECs is an important aspect in context of sustainable aquaculture production. Plant assisted bioremediation is one of the eco-friendly, cost-effective biological methods which is scrutinized to be a possible strategy for the removal of diverse pollutants from the contaminated soil and water. Aquatic macrophytes render a diverse group of aquatic plants, weeds and undesirable vegetation that reproduce their excessive growths with enormous potential for bioremediation of various contaminants. Invasive aquatic weed management is the challenging task. Wide ecological amplitudes of weeds give them advantages over other plants to exploit more successfully disturbed habitat and changed environmental conditions. The circular bioresource economy is based on the concept of involving smart and efficient use of resources and repurpose waste into new resources by optimizing production and consumption systems and reducing harmful discharges to the environment. The prime aspiration of this presentation is to provide the comprehensive review on value addition of aquatic weeds and their bioremediation potential for the removal of CECs present in different types of water bodies.

Invited oral lecture 15

Management of salvinia (*Salvinia molesta* Mitch.) in rice ecosystem

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Salvinia molesta, commonly known as *African payal* is a troublesome free floating aquatic fern, in wetlands of Kerala. In rice, it is becoming a serious weed. Biological control using the weevil *Cyrtobagous salviniae* is recommended only for stagnant water bodies and is not feasible under cropped field situations as it takes long time to get control. Hence a study was undertaken to check the efficacy of a few new generation rice herbicides and ecofriendly measures to control salvinia infestation in rice fields in early establishment stage of rice. The experiment was conducted during September 2021 to August 2022 at the College of Agriculture, Vellanikkara, Thrissur, Kerala Agricultural University. Based on the preliminary studies field experiment was conducted at two locations in central Kerala.

Salvinia was cultured in trapezoidal wide mouthed cement tanks of 0.3 m^2 area and 30 litres capacity. Treatments were, lime and gypsum at 0.1kg/m^2, carfentrazone-ethyl at 0.02 and 0.04 kg/ha, cyhalofop-butyl + penoxsulam and florpyrauxifen-benzyl + cyhalofop-butyl at 0.15 kg/ha, butachlor + penoxsulam at 0.82 kg/ha, 2,4-D amine at 1 kg/ha, acetic acid, salicylic acid, NaCl and copper sulphate each at 5% strength at the rate of 0.05 l/m^2, glufosinate-ammonium at 0.3 and 0.5 kg/ha, and a check. After imposing treatments, phytotoxicity symptoms were observed periodically and scoring was done on a scale from 0-5; 0-none, 1-slight toxicity, 2- moderate control, 3-good control, 4-very good control, 5-complete control. Water samples were collected from tanks 10 days after treatment application and pH, bicarbonate, chemical oxygen demand, and dissolved oxygen were read.After 40 days of treatment application, the highest phytotoxicity scoring of 5 on salvinia was observed in glufosinate-ammonium, florpyrauxifen-benzyl + cyhalofop-butyl, cyhalofop butyl + penoxsulam and butachlor + penoxsulam applied treatments. The next highest score of 4 was observed in carfentrazone-ethyl, acetic acid, salicylic acid and copper sulphate, followed by score 2 for lime, score1 for 2, 4 -D amine and score 0 for gypsum, NaCl and control.

The pH of water was in the range of 6-9 and the highest value was recorded with lime applied treatment. Bicarbonate and alkalinity showed same trend and the highest value was observed with lime. Chemical oxygen demand level above the desirable limit of 1 mg/L was observed with glufosinate ammonium, carfentrazone-ethyl, cyhalofop-butyl + penoxsulam, NaCl, and gypsum. The dissolved oxygen level was within the desirable limit for all other treatments except for lime and copper sulphate.

Based on the pot study, a field trial was done in salvinia infested rice fields at two locations to confirm the efficacy of best treatments in effectively controlling salvinea. It can be concluded that salvinia in rice field can be managed effectively by spraying premix herbicides cyhalofop-butyl + penoxsulam, butachlor + penoxsulam,or florpyrauxifen-benzyl + cyhalofop-butyl. The broad-spectrum herbicide glufosinat-ammonium can be recommended in paddy fields for controlling salvinia during preparatory cultivation.

Oral presentations

Oral lecture 1

Robotic concept derived fuzzy logic based inter-cum intra-row weeder for wider row crops

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Weeds are unwanted plant and compete for nutrients, water, sunlight, and other resources with crops, reducing crop yield by up to 33% or more. Several methods and technologies have been explored for appropriate weed management. These include; manual, chemical, biological and mechanical. The most effective weed control techniques involve manual labour, which is expensive, and herbicides application, which poses serious risks to the environment and human health. Biological methods have also been tried for weed control but are limited due to target distraction and uncontrolled insects resulting in poor efficacy. Mechanical methods are high throughput but are majorly available for managing weeds in the inter-row region. Weeds occur both as inter-row, grow between crop rows, and intra-row weeds which grow between crop plants along the row. Although there are numerous systems available to effectively control weeds in the inter-row zone, the intra-row zone still presents a significant challenge. The use of systems that can effectively control weeds in both the inter- and intra-row zones is required in this situation. System robotic concepts derived for inter- and intra-row weeding that is automated and tractor-operated using fuzzy logic has been developed. The hypothesis is that the system could ensure weeding in both inter- and intra-row region within single pass of the prime mover (tractor). This would ensure a higher weeding efficiency and lower energy expenses. The system consisted of vertical axis rotors (R_{VA}), four-bar linkage (FBL) cranking mechanism and electronic components like ultrasonic sensor, pulse width modulation motors, microcontroller circuits etc. With the help of mechatronics FBL mechanism and fuzzy logic algorithm, crop sensing triggers the electronic control to laterally shift the rotor from intra row crop line. The essential sensors such as depth sensor, ring transducer, torque transducer, load cells, proximity sensor and ultrasonic sensors were calibrated prior to evaluation of intra row weeding system for studying different forces as well as actuation of different mechanisms. The performance evaluation of weeding system was evaluated in soil bin laboratory as well as field. Pertinent to laboratory evaluations, cone index (CI), depth of operation (DO), forward speed (FS), plant spacing (PS) and their interactions had a significant effect on the plant damage that ranged from 0.7–8.7% for all evaluation configurations. Automated inter cum intra-row weeder was evaluated in a chili planted field as per research plan. Dynamic forces like draft, toque and lateral shift force were found to be 1020 N (±20.43 N), 112.97 Nm (SE: ± 10.58 Nm) and 65.05 N (± 2.23 N) at the forward speed (FS) of 2.25 km/h and depth of 40 mm. Actual field capacity was observed in the ranges of 0.16–0.27 ha/h at the FS of 1.3 and 2.25 km/h, respectively. The maximum weeding efficiency was 87.56% (±2.88%), yield critical plant damage was 4.45% and superficial plant damage was 11.11%.

Sensor based pre-emergence herbicide application system for seed drills and planters

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Site specific and precise application of herbicides has become need of the hour for efficient, cost effective and environment friendly weed management. The herbicides are applied in blanket without considering spatial variability of the weeds or weed seed bank, especially in the case of pre-emergence (PE) herbicides. At present, the PE herbicides are applied at 0 to 3 days after sowing of seeds (DAS) as separate operation. In new generation seed drills, an extra attachment is provided for PE application, where herbicide will be applied simultaneously along with seeding. The provided system applies the herbicide in blanket throughout the field, which includes both working and idle time of seed drills. Herbicides applied during idle time will become waste, as there will be no seed is sowed. It has been estimated that, nearly half of the spray liquid was applied during idle time and goes as waste. Therefore, to overcome this problem a Magnetic Hall effect sensor-based pre-emergence (PE) herbicide applicator was developed, where it cutoffs the herbicide application during idle time. The developed system works on the principle of magnetic field detection. It consists of seed drill, Magnetic Hall sensor, spray tank, pump, battery, ground wheel for sensor activation and spray boom. Five flat fan nozzles were used for application of herbicide. A 60% of spray overlap was maintained to get proper spray uniformity. The system was developed in such a way that, where it can be mounted on all types of seed drills and planters with small modification. The total cost of the machine was only around₹ 3000/-, so that, all categories of farmers could able to afford it. The developed system was tested in rice crop and machine performance was compared with two other PE herbicide methods *i.e.* application of PE at 3 DAS as separate operation; application of PE by seed drill while sowing and without spray cutoff. Herbicide application rate of 500 l/ha, pendimethalin 678 g/ha as PE at 0-3 DAS followed by bispyribac-na 25 g/ha as PoE at 18-20 DAS was used in the experiment. It was observed that, the developed system controlled the weeds effectively and had weed control efficiency of 68%. The developed system also saved the herbicide spray liquid by 18-50% compared to PE application by seed drill while sowing and without spray cutoff. Further, the developed system also reduced the operational cost by 1.4 to 2% compared to the application of PE at 3 DAS as separate operation. However, the percentage of herbicide saved was dependent on idle time and herbicide application rate.

WEEDS: A Decision Support System (DSS) for guiding integrated weed management across multiple regions

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Increasing uses of synthetic herbicides and associated issues with herbicide-resistant weeds have made integrated weed management (IWM) a necessity. Knowledge-based tools are urgently needed to maximize long-term sustainable weed control and economic profits. Decision support systems (DSS) can help farmers and practitioners develop effective weed management programs and evaluate for themselves the benefits of adopting and penalties for not adopting best management practices. A simulation model (WEEDS: Weed Ecological and Economic Decision Support) is being developed to support weed management decision-making, targeting driver broadleaf and grass weeds with wide geographical applications. This model is an improvement of the Palmer Amaranth Management (PAM) model that was originally developed for the management of *Amaranthus palmeri* in Midsouthern US. Ongoing improvements include the addition of common waterhemp (*Amaranthus tuberculatus*) and barnyardrass (*Echinochloa crus-galli*), a driver grass weed species. The tool simulates long-term population dynamics of the weed species as well as economic outcomes based on Net Present Value in corn, soybean, and cotton-based rotations. The model will have applicability across wide geographical regions in the United States (US), but current improvements focus on the Midwestern US, in addition to the Southcentral US. The presentation will focus on the structure of the WEEDS decision support tool and the best management practices being emphasized as part of the model simulations.

Allelopathy-based biosynthesized silver nano-particles for the management of water hyacinth

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Water hyacinth is one of the most noxious weeds that has affected agriculture, fishing and livelihoods in Kerala. The explosive growth rate of the weed to a large extent attribute to the eutrophication in water bodies. Biological control of troublesome weeds using biosynthesized nanoparticles is a novel attempt in exploring the prospects of application of nano-particles in agriculture. Use of such eco-friendly nanoparticles may open a door for a new range of nano bio-herbicides. Bio-synthesis of silver nano-particles using plant extracts having allelopathic potential is rapid, cost effective and eco-friendly. Considering the immense potential of biosynthesized silver nano-particles on aquatic weed management, an experiment was conducted at College of Agriculture, Vellayani, Kerala Agricultural University during June 2022 to study the effect of allelopathy-based biosynthesized silver nanoparticles on growth, physiology, and oxidative stress of water hyacinth (*Eichhornia crassipes* (Mart.) Solms). Bio-synthesis of silver nano-particles was carried out as per the standard protocols by treating silver nitrate ($AgNO_3$) with leaf extracts of three weeds having allelopathic properties. The experiment was laid out in pots with design CRD comprising of 10 treatments and 3 replications. The treatments included *Lantana camara* aqueous leachate at 3%; *L. camara* mediated AgNPs at 0.1%; *L. camara* mediated AgNPs at 1%; *Parthenium hysterophorus* aqueous leachate at 3%; *P. hysterophorus* mediated AgNPs at 0.1%; *P. hysterophorus* mediated AgNPs at 1%; *Coleus amboinicus* aqueous leachate at 3%; *C. amboinicus* mediated AgNPs at 0.1%; *C. amboinicus* mediated AgNPs at 1%; Distilled water (control). The biosynthesized AgNPs had phytotoxic effects on the water hyacinth plants. Decreased growth of water hyacinth with chlorotic and necrotic symptoms were observed three days after treatment with *P. hysterophorus* mediated AgNPs at 1% with significantly lower plant dry weight (2.48 g), shoot weight (1.09 g) and root weight (1.39 g) over control and others. Whereas, regarding root weight, this treatment was found on par with *P. hysterophorus* mediated AgNPs at 0.1% and *L. camara* aqueous leachate at 3% (1.72 and 1.65 g), respectively. Further, bio-chemical analysis indicated that *P. hysterophorus* mediated AgNPs at 1% was found significantly different from control with lower chlorophyll (0.393 mg/ml), protein (87.62 µg/g FW), carbohydrate (140.51 µg/g FW) and higher phenol content (144.78 µg/g FW). However, carbohydrate content of *L. camara* aqueous leachate at 3% (151.81 µg/g FW) and *P. hysterophorus* mediated AgNPs at 0.1% (149.84 µg/g FW) were found on par with *P. hysterophorus* mediated AgNPs at 1%. Oxidative stress analysis indicated that SOD content of *P. hysterophorus* mediated AgNPs at 1% (47.58 units/mg of protein) varied significantly with respect to control, but it was found on par with all other treatments. The zeta potential value of the nanoparticles was -32.7 mV which indicated good stability and the particle size was found to be 213.8 nm. Thus, it can be concluded that allelopathy-based biosynthesized AgNPs using *P. hysterophorus* at 1% showed better allelopathic/ bio-herbicidal property for the management of water hyacinth.

Oral lecture 5

A high-clearance self-propelled machine for simultaneous intra-chemical and inter-mechanical weeding in tall field crops: Development and evaluation

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Weeds reduce the yield of many crops by up to 30% if they are not managed at the right crop's growth stage. Although several active and passive weeders are available, they are not suitable for second or third weeding in cotton, pigeon pea, sugarcane, maize, sorghum, and other plants. Weeding and spraying cannot be conveniently performed using normal tractors or power tillers. Expensive solutions are being imported that have variable ground clearance and track width. By keeping this in mind, a study was undertaken to develop a high-clearance, self-propelled machine with a spraying and weeding attachment. The sprayer could do intra-chemical weeding, and the mechanical weeder could do inter-mechanical weeding in tall field crops. A boom sprayer was mounted at the back, and a high-clearance vertical-axis rotary weeder was mounted at the front of the vehicle. The spray boom also has an independent chemical weeding width of 9.4 m. A horizontal cutting concept was adopted in the design of the weeder. Rigorous soil bin experiments at three levels of forward speed, three levels of rotor rotation speed, three levels of depth of operation, and three levels of soil compaction were conducted to finalize the optimum combination of forward speed and rotor speed and the power requirement. It was observed that the required torque for a single rotor unit is about 12–13 Nm at a forward speed of 2 km/h, a 60 mm depth of operation, a rotational speed of 200 rpm, and a compaction level of 600 kPa. The optimal ratios of rotary speed to forward speed (u/v) were in the range of 7.6 to 7.8, which led to thorough pulverization of soil at all compaction levels. The developed five-row weeder and sprayer were tested in vertisol (moisture content: 16.34±0.82 % (d.b.)) with the maize crop planted at 450 mm row spacing. Best performance was observed at rotor speed of 150 to 200 RPM. The field capacity for simultaneous spraying-weeding and full-boom chemical weeding were found to be 0.40 and 1.4 ha/h, respectively. The cost of operation for full-boom spraying and simultaneous spraying and weeding was ₹400 per hectare and ₹1500 per hectare, respectively. Weeding efficiency and plant damage caused by the weeder were 92.58% and 1.55%, respectively.

Nano-atrazine synthesis and application for eco-friendly weed control in maize

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Nanotechnology is the most innovative field of 21st century. Extensive research is going on for commercializing nanoproducts throughout the world. A field experiment was chalked out at College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India to test the efficacy of laboratory synthesized nano atrazine through various pre- and post-emergence treatments of herbicides during *Rabi* 2021 and Summer 2022. The experiment was conducted in randomized block design with ten treatments and three replications. Nano formulation of atrazine was prepared using chitosan and sodium tripolyphosphate (TPP). The nano formulated atrazine was characterized by the Dynamic Light Scattering (DLS), Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FT-IR) to confirm the formation of nano-atrazine. After successful synthesis nano-atrazine, it was used as pre-emergence spray and also post-emergence commercial spray of 2,4-D alone or in combination with nano atrazine was done for controlling maize weeds. The results showed that significantly higher maize grain yield was observed in the weed free treatment to the tune of 57.59, 68.01 and 62.54% and straw yield to the tune of 59.46, 63.19 and 61.24%, respectively during first second, second season and on pooled mean basis over unweeded control. This was followed by recommended atrazine dose (1.0 kg/ha), nano-atrazine application at 87.5% of the prepared formulation as pre-emergence application (PE) + 2,4-D post-emergence application (PoE) and nano-atrazine at 100% of the prepared formulation as a pre-emergence herbicide spray during first season and second season. Among nano-atrazine treatments nano-atrazine at 87.5% of the prepared formulation as a pre-emergence herbicide spray + 2,4-D PoE and nano-atrazine at 100% of the prepared formulation as a pre-emergence herbicide spray had highest maize grain (45.08 and 53.21%) and straw (44.75 and 49.79%) yield during first season and second season. However, on pooled mean basis application of nano-atrazine at 87.5% of the prepared formulation as a pre-emergence herbicide spray + 2,4-D PoE had registered highest maize grain yield (44.75%) over unweeded control. Lowest maize grain yield was registered with unweeded control during both the season and on pooled result.The treatment nano-atrazine at 87.5% of the prepared formulation as a pre-emergence herbicide spray + 2,4-D PoE turned out to be the best combination for weed control in maize crop. Hence, commercial dose of atrazine can be reduced by the use of laboratory synthesized nano-atrazine.

Artificial intelligence based WeedBot for weed identification and removal in dense fields

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Weed detection and removal is one of the major challenges faced by farmers in the field of agriculture. Weeds cause extremely high crop yield losses. Therefore, weeds must be removed from within the fields during their initial stage itself. Detecting and removing weeds from an acre of land requires many laborers and takes several days. This is a time-consuming task and requires huge manpower. Robots replace laborers and do the same task for a lesser duration. Fields that practice row planting do not face many difficulties with weeding as they follow inter-row and intra-row weeding. However, fields that practice broadcasting suffers from the problem of weeding as the weeds are densely populated and it is complicated to identify them. A project was initiated with an objective to build a highly economical and compact robot whose primary objective is to automatically detect and remove weeds from dense fields in less time. As a part of that project, this study was conducted to design an economical, effective, and efficient robot (WeedBot) for small-scale farmers to detect and remove weeds from within the dense fields without human interference. WeedBot works in two crucial steps. In the first step, a Pi Camera is used to capture the field images. To differentiate crop and weeds in the field images, a customized MRCNN (Mask Regional Convolutional Neural Network) model is implemented on the Raspberry Pi computer. This is a trained model with crop-weed images which are pre-processed, augmented, and annotated. This helps the WeedBot to differentiate crop and weed ignoring background and crop. In the second step, the weed is located more precisely. To locate the identified weed more accurately, GPS-RTK (Global Positioning System - Real Time Kinematics) is being implemented for centimeter positioning. Micro doses of organic herbicides are sprayed only on the weed using a robotic arm. This process is repeated until all the weeds in the field are eradicated. WeedBot powers up its components using a solar panel.WeedBot is targeted to implement on any plain land, however, the challenge is to implement it on sloppy, sandy, rocky, or other complicated land surfaces. The outcome of this project will be an agricultural robot that lends hands to small-scale farmers hence, the product will be economical, efficient, and effective. The product is aimed to be designed compactly to easily travel along with fields. Through this robotic weed removal, farmers can attain higher and healthier crop yields in folds. Ultimately, this leads to a reduction in the cost of cultivation of cereal crops, pulses, and vegetables which leads to significant growth in the Indian economy. In developing countries like India, where the majority of the farmers practice small-scale farming, huge robots cannot be implemented and are not affordable as well. Small-scale robots will be of high use as they will ease a farmer’s work and save time, manpower, and money.

Oral lecture 8

Nanoformulation of *Eucalyptus citriodora* essential oil for the control of weeds

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Weeds pose an alarming risk to food security and the livelihood of farming communities. Weeds are the main limiting factor leading to higher yield losses when compared to other crop pests. The constraints in conventional weed control methods, such as the rising labour cost for manual weeding, the evolution of herbicide-resistant weeds, adverse health effects, and environmental issues related to synthetic herbicides, urge researchers to investigate novel weed control methods. Natural metabolites produced from the plant species having allelopathic potential is one of the promising alternative strategies for achieving sustainable and integrated weed control. Allelopathy is natural in plant-to-plant interactions where one plant influences the growth and development of nearby plants by exuding chemicals known as allelochemicals. These allelochemicals enter the environment through leaching, volatilization, decomposition and root exudation. Their mechanisms include photosystem II inhibition, ATP synthesis disruption, excessive production of reactive oxygen species etc. Allelochemicals are a great alternative to herbicides for the management of weeds. These allelochemicals are water-soluble and highly reactive with more stereocenters leading to shorter half-life and instability. Hence, the bioactivity of allelochemicals decreases upon rapid degradation in soils, and allelochemicals become non-effective to control weeds. This demands the development of a suitable delivery vehicle to protect allelochemicals. Nanotechnology offers a promising solution by improving the stability of allelochemicals thereby preventing degradation and also aids in the sustained release for effective weed control. *Eucalyptus* tree species belonging to the Myrtaceae family were reported to possess allelopathic potential against different weed species. *Eucalyptus* essential oil contains terpenoids including monoterpenes and sesquiterpenes, aromatic phenols, aldehydes, alcohol, ketones, ethers and esters. These essential oils can be utilized as bio-herbicides and as an alternative to synthetic weed-control methods.The current study aimed to extract essential oil from *Eucalyptus citriodora* and to develop nanoformulation of the essential oil for weed management. Gas Chromatography-Mass Spectrometry (GC-MS) profiling of the essential oil was performed and the major constituent was found to be citronellal. Oil in water nanoemulsion was fabricated through high energy ultra-sonication technique using the *Eucalyptus citriodora* essential oil, aqueous phase and surfactants. The obtained nanoemulsion was characterized using particle size analyzer with a particle size of 346.3 nm and zeta potential of -30.3 mV. The nanoemulsion was also characterized using Fourier-transform Infrared Spectroscopy and Transmission Electron Microscopy. The developed nanoemulsion has to be further validated against various weed species. This study has a potential scope for developing nano-bioherbicide that works well against noxious weeds by integrating allelopathy and nanotechnology

Bio-efficacy of carfentrazone-ethyl against broad-leaved weeds in wheat and their residual effect on succeeding soybean

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A field experiment was conducted during *Rabi* 2019-20 at Research Farm, Department of Agronomy, College of Agriculture, JNKVV, Jabalpur (M.P.) to evaluate the bio-efficacy of carfentrazone-ethyl 40% DF against broad-leaved weeds in wheat and its residual effect on succeeding soybean. Nine treatments comprising of 5 doses of carfentrazone (12, 16, 20, 40 and 80 g/ha), 2,4-D AM (750 g/ha), metsulfuron (4 g/ha), hand weeding once and weedy check, were carried out in randomized block design with three replications. The result showed that there was pre dominance of dicot weeds in wheat during 2019-20. Among the dicots, *Medicago denticulate* was more ranpant (24.48%) followed by *Chenopodium album* (18.90%), *Melilotus indica* (17.37%), *Cichorium intybus* (17.28%). Whereas *Phalaris minor* (10.66%) and *Anagalis arvensis* (11.31%) were also present. The density and dry weight of all the weeds were maximum under weedy check plots at 30 days after application. However identical reduction in density and dry weight of weeds was observed when carfentrazone was applied at 20 g/ha or higher rates (40-80 g/ha) without any phytotoxicity on wheat plants and attained higher values of weed control efficiency (85.99%). However, the bio-efficacy of carfentrazone-ethyl 40% DF was not much pronounced at different rates against *Phalaris minor* as it is a broad leaved killer. The yield attributing characters namely effective tillers/m^2, grains/ear head, test weight (1000 seeds) were significantly influenced due to various weed control treatments and varied statistically under different treatments at harvest stage. Among the herbicidal treatments, all the yield attributing characters *i.e.* effective tillers/m^2, grains/ear head, and test weight (1000 seeds) were higher in case of early post-emergence of carfentrazone at 20 g/ha and proved significantly superiorto 2,4-D AM (750 g/ha) and metsulfuron (4 g/ha). However, none of the herbicidal treatments surpassed the hand weeding once which had the highest number of effective tillers/m^2 (418.11), number of grains/ear head (79.03) and grain yield (5.70 t/ha). The weed flora in succeeding soybean as well as plant population, growth parameters (plant height, leaf area and branches/plant), yield attributing characters namely number of pods /plant, number of seeds /pod, seed index (100 seeds), seed yield and stover yield of succeeding soybean crop were not influenced due to various weed control treatments applied in preceding wheat crop grown in the orginal layout.

Drip irrigation and mulching reduces weed interference in spring maize

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Spring maize is becoming popular among farmers in Punjab's districts of Hoshiarpur, Kapurthala, Shaheed Bhagat Singh Nagar, Jalandhar, and Ropar, particularly following the early harvesting of toria, peas, potato and sugarcane. Maize cultivation during spring season (February to June) faces severe competition from both summer and winter annual weeds that significantly decrease the grain yield. Thus, developing some novel strategies to minimize weed interferences has become need of the hour to obtain sustainable yields from spring maize. The mulch-drip irrigation system ensures high productivity with less labor and land space while controlling weed growth and pest-diseases to facilitate the management of cultivable land, meanwhile, encouraging farmland management. A field experiment was conducted to study weed dynamics in spring maize as a function of drip irrigation and mulching during spring 2020 and 2021. The factorial experiment was laid out in split plot design with three replications. Main plots consisted of 6 treatment combinations of two drip irrigation methods: surface drip (SD) and sub-surface drip irrigation (SSD) and three mulch levels: black plastic mulch of 25 µ thickness (PM); paddy straw mulch 6 t/h, (SM); and no mulch (NM) along with additional conventional furrow irrigation (without mulching) as a control treatment. Four weed control treatments: atrazine 1000 g/ha as pre-emergence application (PE), hand weeding twice at 30 and 60 days after sowing (DAS), weed free and weedy for whole crop growth period, were in the sub-plots. The combination of drip irrigation and mulches (SD-PM, SD-SM, SSD-PM and SSD-SM) encountered significantly less weed density under the weedy plot during both the years as compared to herbicide treated furrow irrigated control treatment. The plastic mulching results in significanlty less total weed density and biomass as compared to straw mulching and no mulch. Weed density and biomass in weedy-plastic mulched plots were significantly less as compared to atrazine-treated plots under straw mulching indicating the plastic mulch was more efficient in controlling the weeds. Weed density and biomass was observed less under subsurface drip irrigation and plastic mulched plots even without any weed control measures than herbicide treated furrow irrigated control plots. Integration of subsurface drip along with paddy straw mulch and black plastic mulch resulted in 20.6% and 18.3% higher maize grain yield, respectively, as compared to yield obtained from furrow irrigated crop. The grain yield obtained under weedy conditions of SD-PM, SD-SM, SSD-PM and SSD-SM treatments was statistically at par with the yield recorded under weed free conditions of furrow irrigation treatment. Hence, the input cost imposed on weeding operations and herbicides can be saved by the adoption of drip irrigation with mulch.

Oral lecture 11

Response of weed management on growth, yield and yield attributes of *Kharif* maize

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The present study on weed management in *Kharif* maize (*Zea mays* L.) was carried out during *Kharif* 2019 at College Farm, College of Agriculture, Badnapur, Dist.-Jalna. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhnai Maharashtra (India). Randomized block design was used for this study which has ten treatments *viz.* pre-emergence application (PE) of atrazine 1.0 kg/ha, pre-emergence application (PE) of 2,4 –D Dimethyl Amine salt 1 kg/ha, tpramezone 67.2 g/ha PoE at 15 DAS, topramezone 25.2 g/ha PoE at 15 DAS, tembotrione 105 g/ha PoE 15 DAS, topramezone 25.2 g/ha +atrazine 250 g/ha PoE at 15 DAS, tembotrione 105 g/ha + atrazine 250 g/ha PoE 15 DAS, one hand weeding at 30 DAS, weedy check, weed free. Among treatments, weed free recorded more number of leaves, maximum plant height, dry matter production and leaf area per plant followed by topramezone 25.2 g/ha + atrazine 250 g/ha PoE. Poor crop growth was recorded in weedy check. Significantly maximum yield attributes were recorded with topramezone 25.2 g/ha + atrazine 250 g/ha PoE followed by tembotrione 105 g/ha + atrazine 250 g/ha PoE. Minimum values of yield attributes were in weedy check. Weed free treatment (T10) recorded higher number of rows per cob (14 rows) which was at par with topramezone 25.2 g/ha + atrazine 250 g/ha PoE (T6) (13.93 rows) which was at par with tembotrione 105 g/ha + atrazine 250 g/ha PoE (T7) (13.66 rows) and topramezone 67.2 g/ha(13.40 rows). Significantly lowest number of rows per cob recorded in (T9) weedy check (11.17rows). Topramezone + atrazine 25.2 + 250 g/ha PoE was found effective in limiting weed growth and recorded lower weed index, weed biomass with higher weed control efficiency followed by tembotrione +atrazine 105 + 250 g/ha PoE at all growth stages of crop. Lower uptake of nitrogen, phosphorous and potassium by weeds was recorded in treatment of topramezone + atrazine 25.2+ 250 g/ ha PoE followed by tembotrione + atrazine 105 +250 g/ha PoE. The benefit cost ratio was highest (2.94) with topramezone + atrazine 25.2 + 250 g/ha PoE followed by tembotrione + atrazine 105 + 250 g/ha PoE (2.81) whereas weedy check recorded significantly lower B:C ratio(1.50) than other treatments.

Oral lecture 12

Weed indices and yield of maize as influenced by different weed management practices

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An experiment was conducted during *Rabi* 2017-18 at wetland farm of S.V. Agricultural College, Tirupati, Andhra Pradesh, in a randomized block design with ten weed management treatments and three replications. The total weed density and biomass, which included grasses, sedges, broad-leaved weeds as well as total weeds at harvest of corn, higher values of weed control efficiency, weed control index, herbicide efficiency index, crop resistance index and lower weed index were lower with hand weeding twice at 15 and 30 days after seeding (DAS), which was however, comparable with atrazine 1.0 kg/ha as pre-emergence application (PE) followed by (*fb*) topramezone 30 g/ha as post-emergence application (PoE), atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE and atrazine 1.0 kg/ha PE *fb* one HW at 30 DAS without any significant differences among the treatments. The above treatments proved to be better than atrazine 1.0 kg/ha PE *fb* topramezone 15 g + 2, 4-D amine salt 290 g/ha PoE or atrazine 1.0 kg/ha PE *fb* tembotrione 60 g + 2,4-D amine salt 290 g/ha PoE or atrazine 1.0 kg/ha PE *fb* halosulfuron methyl 34 g + 2,4-D amine salt 290 g/ha PoE or atrazine 1.0 kg/ha PE *fb* halosulfuron methyl 67.5 g/ha PoE and atrazine 1.0 kg/ha PE *fb* 2,4-D amine salt 580 g/ha PoE. Better control of weeds in the above treatments could be due to superior weed indices values. Lowest values of weed control efficiency and other weed indices and highest weed index was noticed with weedy check. Highest maize growth parameters, *viz,* plant height, leaf area index and dry matter production, yield attributes, kernel and straw yields were recorded with hand weeding twice at 15 and 30 DAS, which was statistically at par with atrazine 1.0 kg/ha PE *fb* topramezone 30 g/ha PoE or atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE or atrazine 1.0 kg/ha PE *fb* one hand weeding at 30 DAS.

Effect of pre- and post-emergence herbicides on control of weeds in irrigated maize

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Mechanical and chemical methods are more frequently used for the control of weeds than any other methods. Mechanical methods include hand weeding but it is expensive, laborious and time-consuming. Herbicidal weed control is an important alternative to manual weeding because it is cheaper and better weed control can be achieved. Weed control in maize with herbicides significantly increased maize yield and decreased the weed density. However, continuous application of herbicides may cause changes in weed flora, poor control, and evolution of herbicide resistant weed biotypes. Hence, field experiment was carried out at Department of Millets, Tamil Nadu Agricultural University, Coimbatore during *Kharif*, 2021 to identify suitable combination of pre- and post-emergence herbicides for weed management in maize. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated thrice with the following treatments, *viz.* weedy check, weed free check, pre-emergence application (PE) of atrazine 1.0 kg/ha followed by (*fb*) hand weeding at 25 days after seeding (DAS), atrazine 0.75 kg/ha (PE) *fb* post-emergence application (PoE) of topramezone 25.2 g/ha at 25 DAS, atrazine 0.75 kg/ha PE *fb* tembotrione 120 g/ha PoE at 25 DAS, atrazine 1kg/ha PE *fb* topramezone 25.2 g/ha PoE at 25 DAS, atrazine 1kg/ha PE *fb* tembotrione 120 g/ha PoE at 25 DAS, topramezone 25.2 g/ha + atrazine 0.75 kg/ha PoE at 15 DAS and tembotrione 120 g/ha + atrazine 0.75 kg/ha PoE at 15 DAS. The weed management treatments tested evinced significant influence on grassy weeds and broad-leaved weeds. Topramezone at 25.2 g/ha + Atrazine at 0.75 kg/ha PoE on 15 DAS (T_8) recorded lesser grass weed density (19.3 no./m^2) which was followed by T_9 but was superior to T_7 and T_5. With respect to sedges, there was no significant differences amongst treatments. Nevertheless, application of atrazine 0.75kg/ha PE *fb* tembotrione at 120 g/ha on25 DAS(T_5) and atrazine at1kg/ha (PE) *fb* tembotrione at 120 g/ha PoE on 25 DAS (T_7) recorded lesser density (0 and 2.3 No/m^2, respectively). Both the post-emergence herbicides *viz.*, topramezone and tembotrione were highly effective in controlling broad-leaved weeds. Weed management treatments exerted significant influence on yield attributes and yield of maize except grain rows/cob and 100 seed weight. Among the treatments, weed free check (T_2) recorded higher yield (8241 kg/ha), which was comparable with T_8. In respect of pre- and post-emergence herbicides, topramezone at 25.2 g/ha + atrazine at 0.75kg/ ha PoE on 15 DAS (T_8) recorded higher maize yield (6.80 t/ha), which was comparable with T_9 and T_3. Economic analysis revealed that tembotrione at 120 g/ha + atrazine 0.75 kg/ha PoE on 15 DAS recorded the highest net return (₹ 79,025/ha) and B: C ratio (2.81).

Optimizing pre-emergence herbicide dose, methods and time of post-emergence weed management practices for maximizing irrigated maize productivity

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Field experiments were conducted at Maize Research Station, Tamil Nadu Agricultural University, Coimbatore during *Rabi* seasons, 2019-20 and 2020-21 with an objective of optimizing pre-emergence herbicide dose, methods and time of post-emergence weed management practices for maximizing maize productivity. The following pre- and post-emergence weed management treatments were tested *viz*., unweeded check, pre-emergence application (PE) of atrazine 0.25kg/ha followed by (*fb*) hand weeding at 30-35 days after seeding (DAS), atrazine 0.25 kg/ha PE *fb* post-emergence application (PoE) of tembotrione 120g/ha, atrazine 0.25 kg/ha PE *fb* mechanical weeding at 25 DAS, atrazine 0.75 kg/ha PE *fb* hand weeding at 30-35 DAS, atrazine 0.75 kg/ha PE *fb* tembotrione 120 g/ha PoE, atrazine 0.75 kg/ha as PE *fb* mechanical weeding at 25 DAS, atrazine 1.0kg/ha PE *fb* hand weeding at 30-35 DAS, atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE and atrazine 1.0 kg/ha PE *fb* mechanical weeding at 25 DAS. A randomized block design (RBD) replicated trice was used. Tembotrione PoE was applied at 15 DAS and atrazine was applied at 3 DAS. Among the weed management treatments tested, atrazine 1.0kg/ha PE *fb* hand weeding at 30-35 DAS registered significantly lesser grassy (1.67 and 2.55 nos. /m^2), sedges (1.67 and 2.00 Nos. /m^2) and broad-leaved weeds (2.80 and 2.98 nos./m^2); lesser weed biomass (22.2 and 31.2 g/m^2) and maximum weed control efficiency (77.3 and 87.2%) at 15 and 50 DAS, respectively. Whereas at 25 DAS, sequential application of atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE recorded significantly lower weed density of 1.54, 1.84 and 2.97 grasses, sedges and broad-leaved weeds respectively; and also, lower total weed biomass (17.9 g/m^2) and high weed control efficiency (87.9%). It was comparable with atrazine 0.75kg/ha PE *fb* one hand weeding at 30-35 DAS, and sequential application of atrazine 0.75 kg/ha PE *fb* tembotrione 120 g/ha PoE. Atrazine 1.0 kg/ha PE *fb* one hand weeding at 30-35 DAS registered maximum cob length (19.1cm), cob girth (16.7cm), grain rows/cob (14.5), number of grains/row (34.7), grain yield (7.85 t/ha), straw yield (12.87 t/ha), gross return (₹ 130574/ha), net return (₹ 73014/ha) and B: C ratio (2.27). It was comparable with sequential application of atrazine at 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE, and atrazine 0.75 kg/ha PE *fb* hand weeding at 30-35 DAS. It was concluded that IWM practices comprising atrazine 1.0 kg/ha PE *fb* one hand weeding at 30-35 DAS gave effective and economical weed management and higher yield attributes, productivity and economic returns in irrigated maize. In labour scarce conditions, sequential application of atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE could be explored as alternate option.

Evaluation of different weed management practices on yield attributes and yield of maize

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A field investigation was conducted at Annamalai University Experimental Farm, Annamalainagar, to study the "Evaluation of different weed management practices on maize (*Zea mays* L)" during March-June,. The weather of experimental farm was moderately warm with hot summer months. The soil of the experimental field was clay loam in texture. The experiment was laid out in Randomized block design (RBD) with eight treatments and three replications. The eight treatments comprised of unweeded Check, hand weeding twice at 15 and 35 DAS, atrazine 1.5 kg/ha (3 DAS) + one hand weeding, tembotrione 100 g/ ha (21 DAS) + one hand weeding, topramezone 75 g/ha (21 DAS) + one hand weeding, atrazine 1.5 kg/ha (3 DAS) + tembotrione 100 g/ha (21 DAS), atrazine 1.5 kg/ha (3 DAS) + topramezone 75 g/ha (21 DAS), weed free plot. In hand weeding twice were taken up, one at 15 DAS and again at 35 DAS by hand hoeing of weeds. In herbicide treatment, required quantities of herbicides were sprayed as per the treatment schedule. Hand weeding to supplement herbicides in treatments concerned was done on 35 DAS. In weed free, the treatment plots were kept weed free. The fertilizers 250 kg N, 75 kg P, 75 kg K as per the recommendations were applied to the respective plots uniformely. The weed control treatments exert significant influence on cob length, cob girth, number of grains/cob. has recorded the highest cob length of 24.73 cm, cob girth of 10.60 cm, number of grains/cobs of 563.8 which were on par with atrazine 1.5 kg/ ha (3 DAS) + tembotrione 100 g/ha (21 DAS) with cob length of 24.08 cm, cob girth of 10.27 cm, number of grains/cob of 551.24. The unweeded check recorded cob length of 15.70 cm, cob girth of 6.23 cm and number of grains/cob (220). All the weed control treatments have a salutary effect on yield of maize over weedy check. Among the treatments, weed free plot recorded the highest, grain yield of 6.38 t/ha and stover yield 9.98 t/ha which was on par with atrazine 1.5 kg/ha (3 DAS) + tembotrione 100 g/ha (21 DAS) with the grain yield 6234 kg/ha and stover yield 9.78 t/ha. The unweeded check recorded the lowest grain yield 2.40 t/ha and stover yield 6.39 t/ha.

Mateno Duo™ – A novel herbicide for wheat farmers of India to manage hard to manage weeds

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The importance of weed management in winter wheat crop is significant as the crop production and productivity are highly influenced by some of the hard to manage weeds like little seed canarygrass (*Phalaris minor Retz.*) and mixed flora of broad-leaved weeds. Managing little seed canarygrass has become very challenging as it is propagated by seed that grows in multiple flushes in a cropping season and it germinates seasonally depending upon temperature and other agro-climatic conditions including tillage, seeding and soil types. Over the years, this weed has developed cross resistance to most of the herbicide chemistries including ACCase, ALS inhibitor herbicides which is limiting farmers to increase their productivity. Hence, the need of a novel chemistry is highly necessary for successful cultivation of wheat and is also crucial for the integrated weed management for sustainable cropping system. Bayer Crop Science has been working on various sustainable solutions to resolve complexities of weed management in wheat. One of our innovations, Mateno Duo ™, a pre-mix of aclonifen and diflufenican has proved to successfully manage *Phalaris minor* and key broad-leaved weeds in wheat. It offers two mode of action herbicides with aclonifen (HRAC Group 32) inhibiting solanesyl diphosphate synthase and diflufenican (HRAC group 12) inhibiting phytoene desaturase thus inhibiting carotenoid biosynthesis in target weeds. Mateno duo ™ was evaluated in multi-location field trials in *Rabi* season during 2020 & 2021 across Punjab, Haryana and western UP states in India in different tillage (conventional full, zero, minimum tillage) with low to medium *Phalaris minor* along with other broad-leaved weeds *Medicago* spp., *Anagallis* spp., *Brassica* spp., *Chenopodium* spp., *Coronopus* spp., *Melilotus* spp., *Solanum* spp.,). Experiments were laid out in random block design with three replications with an objective of finding selectivity and % bio-efficacy of Mateno Duo ™ for weed control. The product was tested against various reference herbicides *viz.* pinoxaden 5.1%EC, clodinafop-propargyl 24% EC, metsulfuron-methyl 20% WP, sulfosulfuron 75% + metsulfuron-methyl 5% WG, clodinafop-propargyl 15% + metsulfuron-methyl 1% WP. Mateno Duo ™ was observed to offer best protection with better soil residual activity by acting on both root and shoot portion of weeds when applied upto extended pre-emergence stage (0-7 days after sowing) with dose rate ranging from 1050-1200 g ai/ha sprayed using knapsack sprayer fitted with flat-fan nozzle with water volume of 375 L/ha. This novel herbicide pre-mixture also works strongly and consistently across different tillage and residue management practices in north-western Indo Gangetic Plains. Mateno Duo ™ (aclonifen + diflufenican 600 SC) with new mode of action will also offer the opportunity to successfully manage the resistant biotypes of *Phalaris minor Retz.* and provide an effective option to wheat farmers in India.

Impact of drought stress on herbicide efficacy and biochemical traits of wheat

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Crop growth and productivity is greatly influenced by different types of biotic stress (weeds) and abiotic stresses like salinity, drought and extreme temperature. Weed interference can lead to reactive oxygen species (ROS) accumulation in crops. Certainly, these stresses are not completely understood, but play critical roles in crop management, crop development, and reproduction, and often lead to yield loss and reduced farmer profits. Change in antioxidant enzymes was observed in response to stress caused by weed interference and herbicide treatment in crops. Several stress factors cause ROS overproduction and trigger oxidative stress in crops and weeds. An increase in the ROS level in a cell can affect cellular, physiological, and biochemical functions, for example, rupture of the plasma membrane by oxidation of carbohydrates, lipid peroxidation, protein denaturation, and destruction of DNA, RNA, enzymes, and pigments. These in turn result in the loss of productivity and a decrease in the quality of the harvest. Abiotic stress factors like drought stress are one of the major challenges for crop production around the word, and can cause crop yield loses of over 30% and in wheat it was observed that 57% yield reduction. In the near future, drought is expected to increase in many areas, since an anticipated increase in temperature (1.5°C) is expected with each doubling of the atmospheric CO_2 level. Variation in rainfall pattern and increased aridity consistent with a warming climate, could alter weed distribution, herbicide efficacy and their impact on crop production. Therefore, an experiment was conducted to assess the impact of drought stress on herbicide efficacy (clodinafop 60 g/ha + metsulfuron 4 g/ha)] and biochemical traits of wheat. The findings of the study revealed that, effect of herbicide was reduced and altered several biomolecules in wheat under drought as compared to control. In herbicide sprayed treatments, the *M. polymorpha* interference reduced the relative water content (RWC) (%),membrane stability index (MSI) (%), proline content, total phenolic content, protein content, total chlorophyll contentwere decreased by 29.10%, 32.88%, 1.7 fold, 1.1 fold, 48.25% and 54.63% respectively, in wheat as compared to weed free control under drought stress. Similarly, in herbicide sprayed treatments the RWC (%), MSI (%), proline content, total phenolic content, protein content, total chlorophyll content were decreased by 22.94%, 39.25%, 1.59 fold, 1.9 fold, 57.31%, 59.50% respectively, in wheat as compared to weed free control under drought stress. *M. polymorpha* will become a major problematic weed under water scarcity environment. Therefore, the future studies must take into account several abiotic stress factors for providing a way to address the upcoming climate change challenges. Such information will be useful to plant biologists, agronomists and policy makers for developing strategies for increasing or sustaining crop yields under current and future changing environments and management practices to ensure food security.

Weed interference and crop yield under a conservation agriculture-based maize-wheat-mungbean system

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Conservation agriculture (CA) involving minimum mechanical soil disturbance, permanent soil cover with crop residue mulch and diversified crop rotation, plays a crucial role in sustainable crop production. However, weeds pose the most serious threat to CA. A field experiment was undertaken during 2018-19 and 2019-20 to study the effect of conventional tillage (CT) and CA with and without residue using 75 and 100% recommended N dose on weed dynamics and crop productivity. The study was undertaken in the 8th year of a CA-based maize (*Zea mays* L.) - wheat (*Triticum aestivum* L. emend Fiori and Paol) - mungbean (*Vigna radiata* (L.) Wilczek) cropping system at ICAR-Indian Agricultural Research Institute in New Delhi. The experiment was laid out in a randomized complete block design with nine CA-based and one CT-based treatments. CA-based practices with residue retention resulted in a considerable reduction in weed density and biomass when compared to CT. The CT system led to significantly higher total weed biomass in maize due to higher biomass of sedges compared to biomass of grassy and broad-leaved weeds. The dominance of broad-leaved weeds was higher than grassy weeds in wheat under different tillage, residue and crop establishment practices. The CA-based permanent broad and narrow beds with residue retention irrespective of N application were found to be superior towards reducing density of *Phalaris minor* in wheat compared to CA-based flat-bed planting and CT practice. The CA-based narrow and broad-bed practices with residue retention irrespective of N application were found effective in reducing total weed density and biomass compared to CA-based residue removal practices as well as CT practice. CA-based practices had significant impacts in improving growth parameters of maize, wheat and mungbean crops as compared to CT practice. Residue retention had significant impact in positively influencing yield attributing characters of crops than residue removal practices. The CA-based permanent broad bed with residue retention was proved to be a potential management practice for improving growth metrics and yield parameters in maize, wheat and mungbean crops. CA had a significant impact on crop grain yield as well as system productivity as compared to CT. Among the CA-based treatments, the permanent broad bed with residue retention and recommended 100% N application resulted in ~22% higher maize grain yield, ~27% higher grain yield of wheat and ~56% higher mungbean grain yield than CT. Significantly higher two-year mean maize-wheat-mungbean system productivity was also observed under permanent broad bed with residue retention compared to CT, permanent narrow bed and flat bed with and without residue retention plots. The adoption of CA practice involving permanent broad bed with residue retention led to higher weed control efficiency and was found more productive and remunerative. Thus, it could potentially boost up the crop productivity and profitability under maize-wheat-mungbean cropping system in north-western Indo-Gangetic Plains of India.

Ensuing economic benefits through use of different weed management treatments in *Rabi* sorghum - greengram

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Weed scientists must find cost-effective, ecologically based methods to manage undesirable plants. Economic analyses are needed for management, policy making, and setting research priorities. The fundamental economic principle for weed management is simple that to act only if the benefits exceed the costs. However, economics comprise just a small component of research by weed scientists and agricultural economists. Progress in applying economic principles by both researchers and farmers has been spurred by the innovation of decision models for weed management in crops. Doubling of farmer's income would not be accomplished without economic weed management methods. A field experiment was conducted at Instructional Farm, Navsari Agricultural University, Navsari with a view to study the economic benefits obtained through weed management in *Rabi* sorghum (*Sorghum bicolor* L.) under south Gujarat condition. Twelve weed management treatments comprising: unweeded control, weed free, hand weeding (HW) twice and interculturing (IC) at 20 and 40 days after seeding (DAS), pre-emergence application (PE) of atrazine 0.5 kg/ha as, atrazine 0.5 kg/ha PE followed by (*fb)* one HW and IC at 20 DAS, pendimethalin 0.5 kg/ha PE, pendimethalin 0.5 kg/ha PE *fb* one HW and IC at 20 DAS, pendimethalin 0.5 kg/ha PE *fb* post-emergence application (PoE) of 2,4-D 0.5 kg/ha at 20 DAS, atrazine 0.5 kg/ha PE *fb* pendimethalin 0.25 kg/ha PE (tank mixture), atrazine 0.5 kg/ha PE *fb* 2, 4-D 0.5 kg/ha PoE at 20 DAS, atrazine 0.5 kg/ha PE *fb* pyrithiobac-sodium 0.5 kg/ha PoE at 20 DAS and organic mulch (sugarcane trash 2 t/ha, after germination of crop between row) were employed in a randomized block design with four replications. The soil of the experimental field was clayey in texture, low in available nitrogen, medium in available phosphorus and rich in available potassium with alkaline pH. The maximum net returns were recorded with atrazine 0.5 kg/ha PE *fb* HW and IC at 20 DAS which stood as maximum beneficial treatment for *Rabi* sorghum. Whereas, the highest B:C ratio was obtained with atrazine 0.5 kg/ ha *fb* pendimethalin 0.25 kg/ha PE (tank mix) followed by atrazine 0.5 kg/ha PE *fb* HW and IC at 20 DAS. The maximum net returns and B:C ratio in the sorghum-greengram cropping system was recorded with atrazine 0.5 kg/ha PE *fb* HW and IC at 20 DAS followed by weed free treatment in *Rabi* sorghum. No residual effect of the tested weed management treatments was observed on succeeding greengram crop.

Tillage and weed management practices on weed prevalence, crop productivity and economics in maize under maize-chickpea-greengram cropping system

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A field experiment was conducted at ICAR-Directorate of Weed Research, Jabalpur (MP), India during *Kharif* 2021 in long-term conservation agriculture adopted field (since 2012) to know the effect of crop establishment methods and weed management practices on weed dynamics, crop productivity and economics in maize under maize-chickpea-greengram cropping system. The experiment was executed in split-plot design where main plot was assigned to crop establishment methods [conventional tillage (CT) and conservation tillage (zero tillage with full crop residues, ZT+R)], and sub-plots were assigned to four weed management practices [weedy check, recommended herbicides [pre-emergence application (PE) of atrazine 1000 g/ha followed by (*fb*) post-emergence application (PoE) of topramezone 25.2 g/ha, RH], integrated weed management [atrazine 500 g/ha + pendimethalin 500 g/ha as PE *fb* hand weeding at 30 days after sowing (DAS), IWM] and herbicide rotation [tank mix of atrazine 500 g/ha + topramezone 25.2 g/ha as PoE], HR} and replicated thrice. Experimental field was dominated by weeds such: *Echinochloa colona, Dinebra retroflexa, Digitaria sanguinalis, Alternanthera sessilis, Physalis minima, Commelina communis, Amaranthus viridis, Phyllanthus urinaria* and *Cyperus iria* at 60 DAS. Results revealed that adoption of ZT + R coupled with herbicide rotation recorded less weeds and lower biomass with 96.1% weed control efficiency (WCE) followed by ZT + R with IWM, CT with herbicide rotation, CT with IWM and ZT + R with recommended herbicide. However, adoption of CT without weed management recorded the highest weed density and biomass. Among crop establishment methods, ZT+R had comparatively lower weed density and biomass over CT. Lower weed parameters and higher WCE in ZT+R led to obtain better crop growth and yield attributes resulting in higher maize grain yield (6.80 t/ha) and straw yield (9.93 t/ha), which was marginally higher by 3.5 and 19.0%, respectively than CT. Likewise, ZT+R has recorded lower production cost due to saving in tillage operations, labours *etc.* thus recorded higher net returns (₹ 106346/ha) and B: C (3.40) irrespective of weed management practices which was 11 and 12%, respectively higher than CT. Among weed management practices, HR resulted in lower weed parameters, higher growth and yield attributes led to more maize grain yield (7.69 t/ha) and straw yield (10.05 t/ha) although this was statistically ($p<0.05$) comparable with RH and IWM but were superior over weedy check. Yet, HR has recorded 4% more maize grain and 20% higher straw yield over RH which ultimately helped in obtaining higher net returns (₹ 122376/ha) and B: C (3.95) followed by RH and IWM. The lowest grain and straw yield, net returns and B: C were obtained with weedy check.

Effect of herbicide mixtures and nano-urea on weeds and productivity of wheat

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Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world and the second most important food crop of India after rice. By 2050, India's wheat production must increase by at least 31% from its current levels (106.84 mt) in order to meet the country's constantly expanding population demand (IIWBR, 2015; Mo A&FW, 2022). Weeds are one of the most important production constraints in wheat and causing huge reduction in yield. Herbicide resistance, poor nutrient use efficiency, increasing cost of cultivation etc. are the major concerns in weed management in wheat. Hence, to tackle such problems, an experiment was conducted at ICAR-Indian Agricultural Research Institute, New Delhi during *Rabi* 2021–22 to access the effect of herbicide mixture and nano-urea on weeds and wheat (var. *HD 2967*). Herbicide mixtures and nano-urea options were tested in split plot design with 4-nano-urea based nitrogen management *viz*., N_1: control, N_2:100% RDN -120 kg N/ha; N_3:50% RDN + 2-spray of nano-urea at 40 and 60 days after seeding (DAS) and N_4:75% RDN + one spray of nano-urea at 60 DAS) and 4-weed management options *viz.*, W_1 (sulfosulfuron + metsulfuron-methyl (ready mix) 32 g/ha at 30 DAS ; W_2: clodinafop-propargyl of 60 g/ha + carfentrazone-ethyl (tank mix) 20 g/ha at 30 DAS; W_3: weed free check and W_4:un-weeded check). The broad-leaved weeds were the predominant weed-flora in the experiment and *Melilotus indica* was the dominant broad-leaved weed with Summed Dominance Ratio (SDR) of 32.54±1.81 at harvest. Weed density and dry biomass was significantly lower with clodinafop-propargyl + carfentrazone-ethyl (tank mix) as compared to sulfosulfuron + metsulfuron-methyl (ready mix) at 40 DAS, 80 DAS and at harvest. Weed index was also considerably lower in clodinafop-propargyl + carfentrazone-ethyl (7.83%) compared to sulfosulfuron + metsulfuron-methyl (ready mix) (11.79%). Other weed crop competitive indices like agronomic management index, herbicide efficiency index and weed management index were higher with clodinafop-propargyl + carfentrazone-ethyl (tank mix) as compared to sulfosulfuron + metsulfuron-methyl (ready mix). In case of nitrogen management treatments, the lowest weed index value (9.16%) under 100% RDN indicates superior weed management compared to nano-urea based nitrogen treatments viz. 75% RDN + one nano-urea spray (9.49%) and 50% RDN +two nano-urea spray (9.86%). It is mainly due to vigorous growth of wheat that suppressed weeds. The interaction of 100% RDN and weed free resulted significantly higher growth, yield attributes, grain and straw yield and energetics and 100% RDN and clodinafop-propargyl + carfentrazone-ethyl (tank mix). However, the later one was economically superior with higher net B:C (2.14). Soil microbial activities were also higher with clodinafop-propargyl + carfentrazone-ethyl as evident by higher microbial biomass carbon, dehydrogenase and fluorescein diacetate activity at maximum flowering stage of wheat, compared to sulfosulfuron + metsulfuron-methyl. Energy productivity and energy use efficiency was also higher with clodinafop-propargyl + carfentrazone-ethyl (tank mix) than that of sulfosulfuron + metsulfuron-methyl (ready mix). Thus, 100% RDN along with clodinafop-propargyl + carfentrazone-ethyl (tank mix) might be the better option for achieving sustainable yield and profitability of wheat by tackling weed problems.

Oral lecture 22

Weed dynamics and management in wheat in relation with different sowing times and rice residue management systems

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The large scale adoption of long-duration and high yielding rice varieties and increase in agriculture mechanization has led to problem of rice residue management. The combine harvesting leaves stubbles of about 30-40 cm in height. Short sowing window between harvesting of rice and sowing of wheat results in open burning of rice residue in field. Burning of residue leads to emission of harmful gasses and soil degradation, so there is a need for in-situ rice residue management. The shift from conventional tillage to zero tillage in wheat result into weed flora shift. Thus, developing some novel strategies to minimize weed interferences has become the need of hour to obtain sustainable yields of wheat and residue management. Combined adoption of multiple weed control options, both chemical and non-chemical practices like change in tillage practices, residue management (retention or incorporation) will help in effective management of weeds in wheat. A field experiment was conducted to study weed dynamics and management under different rice residue load in relation to wheat planting time and rice residue management systems during *Rabi* 2019-20 and 2020-21. The factorial experiment was laid out in split-split plot design with three replications. Main plots consisted of factorial combination of two rice residue load (PR122 and PR 126) and wheat planting time (25^{th} October and 15^{th} November). The different residue management systems *i.e.* conventional tillage, Happy seeder, mould board plough+ rotavator and burning was kept in sub plots and three weed control treatments (tank-mix of pinoxaden 50 g/ha + metribuzin 175 g/ha, premix of metribuzin plus clodinafop 260 g/ha and weedy plots) was kept in the sub-sub-plots. Weed population per unit area was recorded lower under high rice residue load of PR 122 in first year. In second year, rice residue load has non-significant effect on weed density due to rainfall in early November. Higher population of *Medicago. denticulata* was recorded under early sown wheat whereas, other broad leaf weeds and *P. minor* were recorded lower under early sown wheat. Significantly lower density of different weeds and weed biomass was recorded under Happy Seeder as compared to other rice residue management methods. Weed control by application of metribuzin plus clodinafop 260 g/ha resulted in significantly lower weed population per unit area and weed biomass as compared to weedy, but found statistically at par with tank-mix of pinoxaden 50 g/ha + metribuzin 175 g/ha. Both broad-spectrum herbicides resulted in effective weed control and higher wheat grain yield under rice residue management scenario.

Integrated weed management in wheat

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Wheat (*Triticum aestivum* L.), a member of the Poaceae family, is the world's most valuable staple cereal crop after paddy and contributes significantly to the global economy. In India, the cultivation of wheat is mainly as a *Rabi* crop, and its cultivation is spread between 10-37° N latitudes where rice-wheat is the major cropping system. Wheat is grown in different agro-climatic zones within different crop sequences, as a result of which a diversity of grassy as well as broad-leaved weeds infests this crop. Among grassy weeds, *P. minor*, *Avena fatua,* and among broad-leaved weeds, *Rumex dentatus*, and *Chenopodium album* are the most prominent in the Northern region of the country. In modern intensive agriculture, with a high emphasis on high-cost input farming, weeds have emerged as a major and complex problem in crop production and agricultural technology. Injudicious use of herbicides to control weeds leads to detrimental effects of herbicide residues on human health and the environment. The evolution of herbicide-resistant weed biotypes is a constraint to weed management in many cropping systems around the world. Due to climate change impacts plants are suffering from abiotic stress, and the problems for weed management have become multi-faceted. Weeds are a serious cause of concern for wheat productivity. There is a wide difference between the actual and potential yield of wheat. Effective weed management is one of the improved agronomic practices which can play an important role in minimizing this gap. To solve these complexes weed problems, a holistic approach is required, including adjustments to technology, management practices, and legislation. Now, the focus on crop production has shifted to the development of integrated weed management strategies and eco-friendly technologies with reduced dependency on chemical control methods. Various cultural practices such as nutrient management, tillage, seed rate, spacing, crop rotation, water management, sowing methods, sowing time, and competitive varieties should be followed in such a way that crop plants utilize much more resources in comparison to weed plants. As a mechanical measure, Furrow Irrigated Raised Bed (FIRB) method and stale seedbed technique should be practiced during seedbed preparation for effective weed management. Timely application of herbicides with recommended doses with the help of efficient spray technology improves the efficacy of herbicides. Detailed knowledge about weed phenology, plant breeding, and molecular biology is required for developing effective and sustainable integrated weed management practices. Therefore, for sustaining food grain production and ensuring global nutritional security, effective integrated weed management in the wheat crop is very crucial.

Oral lecture 24

Post-emergence application of imazethapyr on soybean and its residual toxicity effect on performance of succeeding crops in transitional tract of Dharwad, Karnataka

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Soybean (*Glycine max* L. Merrill) is an introduced oil-yielding rainy season (*Kharif*) crop having multiple uses and commercially exploited in India. The crop is mainly cultivated during *Kharif* and is infested with various grassy, sedge and broad-leaved weeds which emerge simultaneously with the crop plants and compete for all growth resources. Pre-emergent herbicides have been recommended; however farmers are preferring the post-emergent herbicides for effective control of weeds in soybean. Hence, it necessitates search for early post-emergence herbicides like imazethapyr for effective and economical control of weeds. Thus experiments was conducted under AICRP on soybean from 2012 and continued as part of Post Graduate studies upto 2019-20 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on vertisols with available N, P and K (252.0, 32.5 and 292.8 kg/ha, respectively) andpH 7.10.The trials were aimed at assessment of post-emergence application (PoE) of imazethapyr against weeds in soybean and in chickpea + linseed intercropping system. The experiment on soybean indicated that imazethapyr 100 g/ha as early post-emergence application (EPoE) proved effective against weeds in soybean (Cv. *JS-335*) ecosystem to achieve higher seed yield (2.5t/ha) without any phytotoxic effect on soybean. However, on succeeding crops like wheat and sorghum. imazethapyr exerted mild residual toxicity with lower germination percentage (80%) for two seasons (2014-2016). Imazethapyr at higher doses (125 and 150 g/ha) was very effective in controlling weeds, but, exerted phytotoxicity on soybean crop. On the basis of these results, the research was continued as part of post graduate studies in order to assess the residual effect of imazethapyr used to manage weeds in soybean during *Kharif* 2017season on performance of succeeding crops like *Rabi* sorghum, wheat, chickpea and safflower during *Rabi* 2017season. The research results indicated that imazethapyr exerted phytotoxic effect on germination of wheat and *Rabi* sorghum (phytotoxicity rating 7 to 9) found very much affected, however such adverse effect was not observed with chickpea and safflower (phytotoxicity rating 1 to 2) during 2017-18. Based on the results, in order to control weeds in chickpea + safflower intercropping system (2:1 row proportion) pre-emergent (PE) application of pendimethalin 30 EC 1 kg/ha and post-emergence application (POE) of imazethapyr 50 g/ha were tried during *Rabi* 2019-20. The experimental results indicated that sequential application of pendimethalin 1.0 kg/ha PE followed by imazethapyr POE 50 g /haproved effective in controlling weeds in chickpea [(cv. *JG-11*) + safflower (cv. *NL-115*)] intercropping system without any phytotoxic effect on chickpea and safflower. It is concluded that imazethapyr PoE could be recommended to control weeds in soybean provided *Rabi* sorghum and wheat crops are not grown as succeeding crops in sequence.

Oral lecture 25

Integrated weed management in Indian mustard

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A field experiment on integrated weed management in Indian mustard (*Brassica juncea* L. Czern and Coss) was carried out in the Agronomy Main Research Farm, College of Agriculture, Orissa University of Agriculture & Technology (OUAT), Bhubaneswar during *Rabi* season of 2021-22. The mustard variety "Sushree" was used. The experiment was laid out in a randomised block design with three replications and consisted of eight treatments *viz*, pre-emergence application (PE) of pendimethalin 0.75 kg/ha, pendimethalin 0.75 kg/ha per ha PE followed by (*fb*) straw mulch 5t/ha, mechanical weeding at 20 days after seeding (DAS), manual weeding at 20 DAS, manual and mechanical weeding at 20 and 40 DAS, straw mulching 10 t/ha at 7 DAS, weed free (hand weeded four times at 20, 40, 60 and 80 DAS) and weedy check. The soil of the experimental field was sandy loam in texture, slightly acidic in reaction (pH-5.92), low in organic carbon (0.42%), low available nitrogen (127.40 kg/ha) and medium in available phosphorus (24.83 kg/ha) and medium in available potassium status (275.38 kg/ha) Mustard experimental field was infested with 16 different types of weeds. The most dominant grass, sedge and broad-leaved weeds in the experimental plot were: *Cynodon dactylon* (11.74%), *Cyperus iria* (5.2%) and *Cleome viscose* (27.86%). Pendimethalin 0.75 kg/ha PE *fb* straw mulch 5t/ha recorded lowest weed density (10.33 no./m^2), weed biomass (1.58 g/m^2), highest weed control efficiency (WCE) of 89.62% and lowest weed index (8.24%). Grain yield and stover yield was also highest with pendimethalin 0.75kg/ha PE *fb* straw mulch 5t/ha (1.13 t/ha and 2.30 t/ha, respectively) and weed free (1233 kg/ha and 2406.25kg/ha, respectively). The highest gross returns were obtained with weed free t (₹ 66,522/ha) followed by pendimethalin 0.75 kg/ha PE *fb* straw mulch5t/ha (₹ 61,115/ha) and straw mulching10t/ha at 7 DAS (₹ 52, 117/ha). However, highest net return was obtained with pendimethalin 0.75 kg/ha PE *fb* straw mulch 5t/ha (₹ 29,995/ha) followed by pendimethalin 0.75 kg/ha PE (₹ 23,979/ha) and mechanical weeding at 20 DAS (₹ 20,679/ha). Weed check recorded lowest gross and net return. Highest net return and B:C ratio was recorded with pendimethalin 0.75 kg/ha *fb* straw mulch 5t/ha (₹ 29,995 and 1.96, respectively) followed by pendimethalin 0.75 kg/ha PE (₹ 23,979 and 1.89, respectively).

Effect of integrated weed management practices on growth and yield of mustard

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Mustard (*Brassica juncea* (L.) Czern and ex. Coss.) is a major *Rabi* oilseed crop of India. Weeds have become the major biotic stress in mustard cultivation. Poor weed management causes low productivity of mustard and yield loss ranges 10-58%. Weed competition in mustard is more projected during early growth stages because crop growth is in low pace during the first 30 days after sowing. The critical period of crop weed competition in mustard is 15-40 DAS and, in this period, weeds cause about 25-50% of yield loss depending on weed flora present and their intensity. The field experiment entitled, 'Effect of integrated weed management on growth and yield of mustard (*Brassica juncea* L.) under lateritic soils of Konkan' was conducted during the *Rabi* season of 2021-22 at the Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri dist., Maharashtra. The experiment was laid in randomized block design which consisted of nine treatments replicated thrice. The treatments comprised of pendimethalin 30 EC (PE) 1.0 kg/ha, quizalofop-p-ethyl 5% EC (PoE) 0.06 kg/ha (25-30 DAS), pendimethalin 30 EC (PE) 1.0 kg/ha (3 DAS) *fb* quizalofop-p-ethyl 5% EC (PoE) 0.06 kg/ha (25-30 DAS), pendimethalin 30 EC (PE) 1.0 kg/ha + hand hoeing (20 DAS) + hand weeding (30-35 DAS), quizalofop-p-ethyl 5% EC (PoE) 0.06 kg/ha (25-30 DAS) + hand weeding (40-45 DAS), pendimethalin 30 EC (PE) 1.0 kg/ha + straw mulch 5 t/ha, quizalofop-p-ethyl 5% EC (PoE) 0.06 kg/ha (25-30 DAS) + straw mulch 5 t/ha, weed free check-hand hoeing (20-25 DAS) + hand weeding (40-45 DAS) and weedy check. The results revealed that, the treatment of pendimethalin 30 EC (PE) 1.0 kg/ha+ hand hoeing (20 DAS) + hand weeding (30-35 DAS) was significantly superior in growth and yield attributes like plant height, number of branches/plant, dry matter/plant, number of siliquae/plant, weight of siliquae/plant, number of seeds/siliquae, weight of seeds/plant and also the maximum yield parameters of seed yield, straw yield, biological yield and harvest index. The weed flora comprised of broad-leaved weeds like *Cardiospermum halicabacum, Celosia argentia, Cleome viscosa, Hibiscus trionum,* and grasees like *Digitaria sanguinalis, Cyanodon dactylon, Oryza sativa L.,* and *Chloris barbata.* The lower weed parameters like number of weeds (m^{-2}), weed dry matter (g/m^2) and weed index, weed persistence index and highest weed control efficiency were recorded in the treatment of pendimethalin 30 EC (PE) 1.0 kg/ha+ hand hoeing (20 DAS) + hand weeding (30-35 DAS) which was followed by weed free check - hand hoeing (20-25 DAS) + hand weeding (40-45 DAS) and quizalofop-p-ethyl 5% EC (PoE) 0.06 kg/ha (25-30 DAS) + straw mulch.

Oral lecture 27

Effect of different weed management practices on yield and economics of mustard

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A field experiment was conducted on sandy loam soils during *Rabi* season, 2020-21. The experiment was laid out in randomized block design with twelve treatments and replicated thrice. The treatments nclude: pre-emergence application (PE) of pendimethalin 1.0 kg/ha followed by (*fb*) post-emergence application (PoE) of quizalofop-ethyl 0.05 kg/ha, oxadiargyl 0.09 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha PoE, oxyfluorfen 0.1 kg/ha PE *fb* quizalofop-ethyl 0.05 kg/ha PoE, pendimethalin 1.0 kg/ha PE *fb* straw mulch 5 t/ha, oxadiargyl 0.09 kg/ha PE *fb* straw mulch 5 t/ha, oxyfluorfen 0.1 kg/ha PE *fb* straw mulch 5 t/ha, pendimethalin 1.0 kg/ha PE *fb* intercultivation at 30 DAS, oxadiargyl 0.09 kg/ha PE *fb* intercultivation at 30 days after seeding (DAS), oxyfluorfen 23.5% EC 0.1 kg/ha PE *fb* intercultivation at 30 DAS, intercultivation and hand weeding at 15 and 30 DAS (weed free), intercultivation at 15 and 30 DAS, unweeded control. The data was analyzed using standard statistical techniques.Among different weed management practices, inter-cultivation and hand weeding twice at 15 and 30 DAS registered lower weed density and biomass and it was on par with pre-emrgence application of oxadiargyl 0.09 kg/ha PE *fb* intercultivation at 30 DAS. Higher weed control efficiency was also noticed with oxadiargyl 0.09 kg/ha PE *fb* intercultivation at 30 DAS. Inter-cultivation and hand weeding twice at 15 and 30 DAS recorded higher crop growth parameters like plant height and drymatter which was on par with oxadiargyl 0.09 kg/ha PE *fb* inter-cultivation at 30 DAS. Similarly significantly higher yield attributes (number of siliqua/plant and number of seeds/pod), yield, gross and net returns, higher nutrient uptake by the crop and lower nutrient removal by the weeds were recorded with intercultivation and hand weeding at 15 and 30 DAS and it was comparable with oxadiargyl 0.09 kg/haPE *fb* inter-cultivation at 30 DAS. However, higher B:C ratio was obtained with oxadiargyl 0.09 kg/ha PE *fb* intercultivation at 30 DAS.

Evaluation of chemical cum mechanical weed management – A way to reduce chemical usage in sunflower

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Sunflower (*Helianthus annuus* L.) is one of the primary important oilseed crops in the world. Amongst various production factors, weeds are one of the important factor to the crop cultivation, because they compete with the other production factors such as moisture, nutrient, light and space and ultimately affect the crop productivity. A field experiment was conducted at Department of oilseeds farm of Tamil Nadu Agricultural University, Coimbatore during *Kharif,* 2019. The experiment with a set of ten treatments comprising pendimethalin (30 EC) 1.0 kg/ha as pre-emergence at seed row (after irrigation) + power weeder at 15-20 and 30-35 DAS, pendimethalin (30 EC) 1.0 kg/ha as pre-emergence at seed row (before irrigation) + power weeder at 15-20 and 30-35 DAS, pendimethalin (38.7 CS) 1.0 kg/ha as pre-emergence at seed row (after irrigation) + power weeder at 15-20 and 30-35 DAS, pendimethalin (38.7 CS) 1.0 kg/ha as pre-emergence at seed row (before irrigation) + power weeder at 15-20 and 30-35 DAS, pendimethalin (30 EC) 1.0 kg/ha as pre-emergence+ power weeder at 30 DAS, Pendimethalin (38.7 CS) 1.0 kg/ha as pre-emergence + power weeder at 30 DAS, two weeding by power weeder at 15-20 and 30-35 DAS, pendimethalin 1.0kg/ha as pre-emergence + HW at 30 DAS, weed free control and unweeded control was laid out in randomized block design with three replications. Pre-emergence herbicides for the treatments before irrigation was done after sowing and just before irrigation and for after irrigation treatments were applied on 3 DAS. In the experiment grassy weeds like *Cynodon dactylon, Setaria verticiliata, Dactyloctenium aegyptium and Echinocloa colona, Sedges like Cyperus rotundus* and broad-leaved weeds like *Trianthema portulasatrum, Digera arvensis and Parthenium hysterophorus* were the dominant ones. Pre-emergence application of pendimethalin as pre-emergence spray *fb* power weeder weeding gave excellent control of all the weeds at all the stages of the crop and it recorded higher weed control efficiency and the lowest weed index. This combination also resulted in significant increase in growth and yield attributes of sunflower and it was comparable with twice hand weeding and pre-emergence application of pendimethalin 1.0 kg/ha *fb* hand weeding or power weeder weeding at 30 DAS. Weed free environment resulted in producing significantly higher seed yield of 2212 kg/ha and it was on par with pre-emergence application of pendimethalin *fb* hand weeding or power weeder weeding at 30 DAS and pendimethalin as pre-emergence at seed row + power weeder at 15 & 30 DAS except pendimethalin (30 EC) 1.0 kg/ha as pre-emergence at seed row (before irrigation) + power weeder at 15 and 30 DAS. Highest net returns of₹ 18,581 /ha and benefit cost ratio of 1.34 was obtained in pendimethalin (38.7 CS) 1.0 kg/ha as pre-emergence at seed row (After irrigation) + power weeder at 15 and 30 DAS. Hence, to control weeds effectively and economically in sunflower application of pendimethalin (38.7 CS) 1.0 kg/ha as pre-emergence at seed row (After irrigation) + power weeder at 15 and 30 DAS is suggested.

Effect of integrated weed management and organic manures in sunflower

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A field experiment was conducted in the experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema campus, Nagaland during the summer period of April-July 2021 to study the "Effect of integrated weed management and organic manures in sunflower (*Helianthus annus* L.)". The objectives of the experiment were: 1. To study the effect of integrated weed management on the growth and yield of sunflower. 2. To study the effect of organic manures on the growth and yield of sunflower. 3. To find out the economics of different treatments under study.The experimental design was randomized block design (RBD) with three replications. The sunflower variety '*KBSH-41'* was used which is a variety developed by AICRP (Sunflower) centre, University of Agricultural Sciences, Bengaluru, Karnataka. The treatments consisted of weed management practices weedy check, weed free, pre-emergence application of pendimethalin at 1.0 kg/ha *fb* one hand weeding at 25 DAS, post-emergence application of oxyfluorfen at 0.24 kg/ha at 25 DAS *fb* one hand weeding at 50 DAS, pre-emergence application of pendimethalin at 1.0 kg/ha + post-emergence application of oxyfluorfen at 0.24 kg/ha at 25 DAS and organic manures- FYM at 15 t/ha and pig manure at 10 t/ha. From the experimental findings, it was recorded that weed free gave the highest control of weed population resulting in lowest weed dry weight and highest weed control efficiency among the different weed management practices and thus recorded the highest growth and yield of sunflower (1.61 t/ha). Application of herbicides greatly reduced the population of weeds resulting in good weed control. Among the herbicidal treatments, oxyfluorfen at 0.24 kg/ha as post-emergence recorded a better result next to weed free in most of the weed control parameters and plant growth with highest yield of 1.47 t/ha. Organic manures did not show any significant influence on the weed management. However, application of pig manure showed better result than farmyard manure in all the growth parameters. A treatment combination of weed free + pig manure at 10 t/ha gave the highest gross returns (₹ 193,029/ha), highest net returns (₹ 127,109/ha) and highest benefit cost ratio (1.92).

Oral lecture 30

Bio-efficacy of different herbicides on weeds and their impact on fresh fruit bunch (FFB) yield of oil palm

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Oil palm (*Elaeis guineensis*) is a perennial crop growing for the production of palm oil. It is one of the highest oil yielding crops derived from the mesocarp (reddish pulp) of the fruit among the all-perennial crops. Weeds compromise crop productivity through competition for plant resources including water, soil nutrients and light. Herbicides have proven to be useful for controlling weeds in the oil palm and can drastically save cost of labor. Two or more herbicides may need to be combined in one spray application (tank-mix) to achieve adequate weed control. Combinations may include one or more pre-emergence herbicides or a mixture of pre-emergence and post-emergence herbicides. A field study was conducted to evaluate the bio-efficacy of different herbicides on weeds and their impact on fresh fruit bunch (FFB) yield of oil palm' (10 years old plantation) for two years, on medium black soils of Agricultural Research Station (ARS) campus, Gangavathi, University of Horticultural Sciences, Bagalkot, coming under Northern dry zone of Karnataka. The experiment was laid out in a randomized complete block design with four replications. Weed vegetation analysis was conducted before herbicide treatments were imposed. Herbicide treatments used were: indaziflam (37.5, 50, 62.5 and 125 g/ha), diuron (1600 g/ha), glyphosate (1230 and 2460 g/ha) and glufosinate ammonium (100 g/ha) at 4-6 leaf stage of weeds with untreated control. The major weeds were *Euphorbia hirta, Euphorbia geniculata, Parthenium hysterophorus, Cynodon dactylon, Malvastrum coromandelinam, Cyperus rotundus, Acalypha indica* and *Tridax procumbes.* During 1st year, weed density at 60 DAS, application of indaziflam + glyphosate 125 g/ha as post-emergence spray governed the densities of weeds (13.0 /m^2) and the densities were statistically similar to the plots sprayed with indaziflam 50 or 62.5 g/ha and indaziflam + glufosinate ammonium 62.5 + 500 g/ha (14.0/m^2). During 2nd year at 60 DAS, application of indaziflam + glufosinate ammonium 125 + 1000 g/ha as post-emergence spray lowered the densities of weeds (1.33 /m^2) and it was followed by the application of indaziflam 125 g/ha and indaziflam + glyphosate 125 + 2460 g/ha as post-emergence (3.56 and 3.54 /m^2). The treatment receiving pre-emergence application of indaziflam 125 g/ha recorded significantly lower dry weight of weeds compared to other treatments. The percentage of weeds controlled was significantly affected by the treatments of indaziflam 125 g/ha as pre-emergence, indaziflam + glyphosate and indaziflam + glufosiate ammonium as post-emergence relative to the untreated control, with at least more than 45% weed control observed at 30 DAS. Indaziflam at lower rates of 37.5 and 50.0 g/ha was considered to be less effective in controlling the weeds in this mixed weed condition. The significantly higher FFB yield of 16.4 t/ha was observed in highest weed control treatment when compared to control (14.2 t/ha). In oil palm, new herbicide indaziflam 500 SC 62.5 or 125 g/ha as pre-emergence or indaziflam in combination with glyphosate or glufosinate ammonium as post-emergence was effective up to 90-120 DAS as revealed by weed count and weed dry weight. Thus, new indaziflam 62.5 or 125 g/ha as pre- and post-emergence is quite safe for oil palm in medium black soils under irrigated condition.

Management of complex weed flora in onion

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Onion (*Allium cepa* L.) is one of the most important flavoring vegetable crops. Onion is heavily infested by the weeds due to its slow growth, non branching habit and very less and erect plant canopy. Due to non-availability of timely labour, weeds are not controlled at the proper stage of the crop resulted in drastic reduction in yield of onion bulb. Hand weeding and interculturing are very cumbersome and causes injury to the plant which results in the purple blotch disease. Hence, the use of herbicides is one of the options available with the farmers to eliminate crop weed competition at early growth stage in onion. Hence, this experiment was conducted at AICRP on Weed Management Farm, Anand Agricultural University, Anand during *Rabi* season of the year 2020-21 on loamy sand soil with twelve treatments and three replications to manage complex weed flora. Experimental field was infested with complex weed flora and the overall dominance of dicot weed (77.0%) was observed during the experimentation period. Major weed species observed in the experimental field were *Eleusine indica* (9.63%), *Asphodelus tenuifolius* (7.76%), *Dactyloctenium aegyptium* (2.48%) and *Setaria glauca* (1.86%) as monocot weed while *Chenopodium album* (54.0%), *Melilotus alba* (13.7%) and *Chenopodium murale* (8.07%) as dicot weed. Weed control efficiency of monocot, dicot and total weeds were recorded 100 per cent at 50 daysafter transplanting (DAT) with pre plant incorporation (PPI) of pendimethalin 580.5 g/ha followed by (*fb*) post-emergence application (PoE) of oxyfluorfen 120 g/ha, pendimethalin 580.5 g/ha PPI *fb* oxadiargyl 75 g/ha PoE and oxyfluorfen 120 g/ha PE *fb* propaquizafop 5% + oxyfluorfen 12% w/w EC (pre-mix) 43.75 +105 g/ha PoE. Significantly higher onion bulb yield (43.7 t/ha) was achieved with pendimethalin 580.5 g/ha PPI *fb* oxyfluorfen 120 g/ha PoE closely followed by propaquizafop 5% + oxyfluorfen 12% w/w EC (PM) 43.75 +105 g/ha PoE, pendimethalin 580.5 g/ha PPI *fb* oxyfluorfen 120 g/ha PoE and pendimethalin 580.5 g/ha PPI *fb* oxadiargyl 75 g/ha PoE with higher B:C.

Effect of different weed management options in vegetable pea

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In the face of looming labour shortages, energy crises, soil erosion, and herbicide resistance development in the agricultural sector, integrated weed management (IWM) is an emerging weed management technology. Because of the diverse and complex weed flora associated with different crops, the increasing trend in adoption of IWM has resulted in increased interest in improving weed management strategies. As a result, during the *Rabi* season of 2021, a field experiment consisting of eight weed control treatments replicated thrice at the Research farm, Division of Agronomy, ICAR-Indian Agricultural Research Institute in New Delhi to assess the efficacy of different sequential herbicide applications (pre- and post-emergence) as well as mechanical weeding on weed interference, crop productivity and economics. The soil of the experimental site was sandy loam with a pH of 7.8, 0.41% organic carbon, a bulk density of 1.52 g/cm^3, and available N, P, and K of 221, 13, and 241 kg/ha, respectively. The results showed that applying pendimethalin (750 g/ha) as pre-emergence application (PE) followed by (*fb*) mulch followed by (*fb*) pre-mix of (metribuzin + clodinafop) 270g/ha as post-emergence application (PoE) significantly reduced weed growth (density and biomass) and significantly increased weed control efficiency and weed control index (60.58 and 60.40%, respectively). When compared to the unweeded control (2.99 t/ha), this combination increased crop productivity by 1.39 times (39%). Apart from that, mechanical weeding done at 25 and 50 days after sowing (DAS) and sequential application of pendimethalin 750 g/ha PE, *fb* mulch, *fb* quizalofop-p-ethyl 50 g/ha PoE resulted in a lower weed density, increased crop growth, and increased pod yield (4.14 and 4.05 t/ha, respectively). Mechanical weeding had the highest net returns (₹ 1,63,654/ha) and net BC ratio (3.78), followed by sequential application of pendimethalin *fb* mulch *fb* (metribuzin + clodinafop) (₹ 1,63,404/ha and 3.67, respectively) as these treatments increased pod yield and profitability without adding much to production costs. As a result, appropriate combinations of pre- and post-emergence herbicides, as well as other weed management options such as mechanical weeding, can be used to achieve higher herbicide efficacy, better weed control and improved productivity and profitability of the vegetable pea.

Impact of post-emergence herbicides on soil microflora in transplanted rice

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Herbicide use in rice that has been transplanted may change the biological balance of the soil and have an impact on its nutrient status, health, and productivity. During samba 2021 and navarai 2022, field study was conducted at the Annamalai University Experimental Farm to examine the impact of herbicides on the soil microbial community of rice variety '*BPT 5384*'. Eight weed control treatments *viz.* flucetosulfuron 15 g/ha, flucetosulfuron 20 g/ha, flucetosulfuron 25 g/ha, flucetosulfuron 30 g/ha, Hand weeding twice on 20 and 40 days after transplanting (DAT), bispyribac-sodium 20 g/ha, azimsulfuron 70 g/ha and unweeded control, were tested. The experiment was replicated three times using a randomised block design. The observations were taken on the day of application (DAA), 30 DAA, 60 DAA and 90 DAA. The viable microbial counts were analyzed by the standard technique of serial dilution and pour plating. The bacterial population was estimated by growing on soil extract agar. The population of actinobacteria was grown on dextrose nitrate agar culture media. The fungal population was cultured on rose Bengal agar culture media. Statistical significance of the treatment effects on different parameters was determined. There was seasonal variation found in the microbial population at different periodical observations and seasons of study. The herbicides and their degradation products generally take some time to accumulate in the soil and then affect the soil microflora. Actinobacteria were less affected as compared to bacteria and fungi. Actinobacteria are reported relatively resistant to herbicides and get affected at high concentration that the microbial populations were not significantly affected by different weed control treatments. But on later stages on 30 DAA and above the microbial populations in the herbicide treated plots were more or less similar to the control plots (unweeded and hand weeding) thus indicating that herbicides have no detrimental effect on soil health at the applied doses. Thus, various weed management methods tested during both seasons had variable effects on the viable microbial community. When used at the prescribed rates, the herbicides flucetosulfuron at various doses, azimsulfuron, and bispyribac were safe for soil microbial communities.

Bioremediation of pretilachlor by bacterial consortia from polluted soils of Assam

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Herbicides have been used for managing the weeds in agricultural lands and aquatic bodies. Herbicides, as a tool for weed management, are gaining immense popularity as it provides economic, efficient, and timely control of weeds. Farmers often use the herbicide(s) without considering either long or short-term effects on soil, water, and food chain as well as on its natural habitats. The residual effect of herbicides in the environment is mostly influenced by their degradation pattern and their half-life ($T_{1/2}$). However, the half-life is not absolute because it depends on the soil type, temperature, and concentration of the herbicide applied. Microbes play an important role in degradation as well as counteracting the residual effect of herbicides. The continuous use of the herbicide pretilachlor belonging to chloroacetanilide group used as a pre-emergence herbicide against grasses and broad-leaves weeds has called the special attention due to the multifaceted toxicity, persistence of the herbicide molecule in soil and their final entry in entire food chain. The build-up of herbicide residues in soil affecting the soil microbial community that is primarily involved in nutrient cycling and crop residue decomposition resulting in poor soil health. In cognizance of the above, a laboratory pot study was conducted to understand the consequences of bacterial consortia on pretilachlor-treated soil. The treatments comprised of: pretilachlor 750 g/ha pretilachlor 750 g/ha + vermicompost 2 t/ha, pretilachlor 750 g/ha + bacterial consortia 10 ml /6 kg soil and pretilachlor 750 g/ha + vermicompost 2 t/ha + bacterial consortia 10 ml/6 kg soil. Randomised complete block design with four replications was used. Bacterial consortia of (52.32 – 782.4) x 10^6 CFU/g soil were inoculated to the pots at 10 ml per 6 kg soil with 30% soil moisture content. All together 26 bacterial cultures were isolated, out of which 4 from coal, 8 from petroleum oil, 3 from brick, 5 from cement, and 6 from paper-polluted soil using specific media. Identification of the bacterial isolates was done by sequencing of 16SrRNA and phylogenetic tree of which most of the bacteria belong to the strains *Bacillus, Pseudomonas, Fictibacillus* and *Acinetobacter*. Soil samples were collected periodically from the day of herbicide application (within 4 hours of application) till 30 days after application (DAA) of herbicides and detection of herbicide residue was done in GC-1000 with Electron Capture Detector (ECD). The treatments pretilachlor 750 g/ha + bacterial consortia 10 ml /6 kg soil and pretilachlor 750 g/ha + vermicompost 2 ton/ha + bacterial consortia 10 ml/6 kg soil with bacterial consortia resulted in faster degradation with shorter half-lives of pretilachlor than the treatments pretilachlor 750 g/ha and pretilachlor 750 g/ha + vermicompost 2 t/ha without bacterial consortia. The degradation of the herbicides in soil followed a first-order kinetic. It was also evident from the degradation pattern that the single herbicide doses degraded slowly at the beginning of the experiment over the doubled herbicide dose which can probably be explained by the microorganisms' adaptability to the higher doses.

Residues and persistence of pendimethalin in chickpea

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A field experiment was conducted during *Rabi* 2018 and 2019 at Anand Agricultural University, Anand, Gujarat with other three locations, *viz*. University of Agricultural Sciences, Raichur, Karnataka; Mechanized Agriculture Farm, Ummedganj, Kota and Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP. The dissipation study in chick pea plant and residues study in green pod, dry pods and soil was carried out at AAU, Anand, while only harvest time residues in dry chickpea pod and soil was studied at other three locations. This herbicide is not recommended in chickpea in India. Hence, to generate the information on persistence and residues of pendimethalin in chickpea plant, green chickpea pod, dry chickpea pod and soil, the present experiment was conducted at multilocation trial as per Good Agricultural Practices (GAP). The information generated would help fixing up MRL and PHI for label claim. The quantitative analysis of the herbicide residues was performed using Gas Chromatography using ECD detector. The QuEChERS method was used for the estimation of residues in leaves, pods and soil. For the suitability of method for extraction, the recovery was carried out at 0.05, 0.25 and 0.50 mg/kg fortification levels in all matrix, *viz.* leaves, green pods, dry pods as well as in soil. The recoveries were found in the acceptable range as per the SANTE guidelines. Pre-plant incorporation of pendimethalin in chickpea at 677.25 and 1354.45 g/ha resulted in residues of pendimethalin in chickpea plant were below determination level of 0.05 mg/kg at either dose in all samples collected at 30, 35, 40, 45 and 50 days after application. The residues of pendimethalin in green pod also was below the determination level of 0.05 mg/kg in standard and double dose, when collected at 101 days after application. The dry pod and soil collected at harvest did not reveal any residues of pendimethalin in both the dosages. The results on residues of pendimethalin at other location revealed residues in dry pods and soil were below determination level of 0.05 mg/kg in both the doses when samples were cellected at harvest.

Effect of herbicide on soil biochemical properties under varying level of crop, nutrient and herbicide dose in wheat under vertisols of Central India

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Research from the past highlighted that herbicide application in the crop field directly or indirectly influences various soil biochemical activities like microbial biomass carbon (MBC) and soil enzymatic activities like dehydrogenase (DHA), urease (URE), acid phosphatase (ACDP) and alkaline phosphatase (ALKP) activities which are linked with carbon and nutrient cycling; mostly of them confined to lab incubation study using very high dose (5X, 7.5X and 10X dose, X= recommended dose) of herbicide application and very few had been reported under actual field condition. Further it was reported that application of soil amendmends like organic matter, nutrients and presence crop rhizosphere greatly modifies the negative impact of herbicides at initial periods. Keeping all these in view, an experiment had been laid out in factorial randomized block design (FRBD) using 3 factors namely, factor A- crop (C1) vs non crop (C0) (to isolate rhizosphere effect), factor B – soil amendments *i.e,* control (F0, receiving no external inputs), RDF (F1, recommended dose of fertilizer, 120-60-40 kg NPK/ha), RDF + 3 t crop residue (F2) and factor C – herbicide dose, such as, no herbicide (H0), field recommended dose (H1, 1X, 4 g ai / ha) and double recommended dose (H2, 2X, 8 g/ha). Soil samples form 0-15 cm were collected from crop plot (rhizosphere soil sample) and non-crop plot (non-rhizosphere soil) at different days intervals, *viz.* 1,15,30,45 and 60 days after herbicide application (DAHA). Results highlighted that, there was deleterious effect of herbicide at 2X dose in soil MBC, dehydrogenase, acid phosphatase and acid phosphates activities immediately after herbicide application (1 and 15 DAHA). This immediate suppression effect was more visible in non crop plots (absence of rhizosphere effect) and plots receiving no external inputs. Application of soil amendments such as RDF and RDF + crop residue and presence of crop minimized the suppression effect of herbicides even at 2X dose. At later sampling time, this initial suppression effect of herbicides on MBC and other soil enzymes gradually disappeared and showed stimulation effect. At 60 DAHA, we observed that application herbicide had no negative effect on soil biological parameters. It can conclude thatunder field conditions, herbicide had no negative effect on soil biological health if applied at field recommended dose along with adoption of good crop management practices (balanced fertilization and crop residue recycling) which will curb the ill effect of herbicides on soil functioning.

Residue status of diclosulam in soybean

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Diclosulam, a triazolopyrimidine sulfonamide class of herbicide, is one of the new molecules which is highly effective for controlling broad-leaved weeds. It inhibits acetolactate synthase (ALS), the enzyme responsible for biosynthesis of branch-chain amino acids and thereby cell division and growth of the weeds are quickly arrested. As an active ingredient, diclosulam has activity both soil applied and post-emergence. It can be soil applied in any tillage system since it does not require incorporation. The herbicide is a highly active, low dose compound. Its longevity in the soil makes diclosulam ideal for control of broad-leaved weeds in soybean and peanuts. A field experiment was conducted at Anand Agricultural University, Anand, Gujarat to study the residue status of diclosulam 84% WG in soybean. The pre-emergence application (PE) of diclosulam at 26 and 52 g/ha was done at one day after sowing with knapsack sprayer for the control of weeds. Various plant parts, *viz.* soybean leaves, dry pods and soil were collected at the time of harvest (113 days after application) and the diclosulam residue analysis was carried out in leaf, dry pods, oil and soil. From the dry pods, seeds were collected and extracted for total oil by using soxhlet extractor and the collected oil was used for further analysis of diclosulam residue. The quantitative analysis was performed using Liquid chromatography-Mass spectrometry (LC-MS/MS). The QuEChERS method was used for the estimation of diclosulam residue. For the suitability of method of extraction for diclosulam, the recovery studies were carried out at 0.05, 0.25 and 0.50 mg/kg fortification levels in all matrix *viz.* leaves, pods, oil as well as in soil. The recoveries were found in the range of 88.00-109.07%, 95.07-99.67%, 98.47-104.67%, 91.33-111.60% in leaves, dry pods oil and soil, respectively. These recoveries were found in the acceptable range as per the SANTE guidelines for pesticide residues. The result of analysed samples revealed that the diclosulam residues were found below determination level of 0.05 mg/kg in leaves, dry pods, oil and soil.

Cereal rye residue effects on the germination of troublesome weeds in the Southern United States

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In the southeastern United States, pigweeds (*Amaranth* spp.), morning glory (*Ipomoea purpurea*), nutsedges (*Cyperus* spp.), sicklepod (*Senna obtusifolia* L.), and large crabgrass (*Digitaria sanguinalis* (L.) Scop.) are the major weed species threatening crop production system. Increasing number of herbicide-resistant weeds is becoming a major problem to traditional chemical weed control. It is necessary to have sufficient knowledge about weed seed dormancy and biological germination to advance the management strategies in the cropping system (Zeidali *et al.* 2021). Meanwhile, cover crop adoption in the southeast has gained significant popularity among row crop farmers. Effects of cover crop residue on weed seed germination warrant further evaluations. It is necessary to have sufficient knowledge about weed seed dormancy and biological germination to advance the management strategies in the cropping system. Weed seed germination and early growth stage are critical part of the weed life cycle that is controlled by both environmental and genetic factors. Therefore, weed control strategy should be focused on the most susceptible parts of the weed cycle to maintain sustainability and reduce the use of the chemical herbicide. Cover crops have been increasingly adopted to suppress weed germination and vigorous vegetative growth. A greenhouse experiment was conducted to evaluate the germination and growth response of several key weeds in the Southeast to various levels of cereal rye residue. Seeds of palmer amaranth, sicklepod, morning glory, and crabgrass were mixed with organic garden soil and placed over the top of the tray. The soil flats were covered uniformly by four different biomass of rye straw. Plant growth was quantified through weed counting and recording of dry weight. Data were analyzed with PROC GLIMMIX in SAS® for mean separations with Fisher's protected LSD at á=0.05 level. SigmaPlot v. 9.4 was used for curve-fitting regressions and estimation of model coefficients and R-square values. The results illustrated that the p-value was not significant for non-linear regression on weed count and biomass of morning glory. Meanwhile palmer amaranth, sicklepod, and crabgrass showed significant germination pattern and dry weight differences under different biomass of cereal rye. The morning glory was least responsive to increasing biomass, and palmer was the most responsive one due to small seed sizes. While germination and growth rate of crabgrass and sicklepod have fluctuated with different levels of biomass residue during this greenhouse study. Seed size is a major attribute of its quality because large seeds favor vigor germination, establishment, and growth rate due to more stored resources. Our data supports these conclusions. Future research is needed to study the germination response of these weed species affected by various levels of cereal rye biomass and soil herbicides under field conditions.

Weed dynamics and atrazine residue in green fodder and silage of spring maize grown under different cropping systems in north-west India

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Spring maize is cultivated on large area for silage making in north-west India. Silage of spring maize ensures round the year fodder availability, thus helps to sustain the milk yield of dairy animals and overall net returns of the commercial dairy farmers. Weed management is a big challenge in spring maize and atrazine is commonly used for weed control. There is increasing concern of atrazine residue in fodder and silage as it is a residual herbicide. A field study was conducted during 2020-21 and 2021-22 at Punjab Agricultural University, Ludhiana to quantify atrazine residue in spring maize grown under different cropping systems. Atrazine residue in green fodder and silage was quantified to ensure the safety of milch animals. Spring maize (cv. *PMH 10*) was grown as fodder for silage making in three maize-based cropping systems {maize - oat (*Avena sativa* L.)/ toria (*Brassica campestris* L.) / *gobhi sarson* (*Brassica napus* L.) - spring maize (Silage making)}. Pre-emergence application (PE) of atrazine 1.0 kg/ha was done in spring maize grown under different cropping systems along with unweeded as weed control treatments. The experiment was conducted in randomized complete block design with 3 replications. Spring maize was harvested along with cobs at milk stage [78-98 days after sowing, (DAS)] for fodder and silage making. The silage was prepared after 45 days of anaerobic fermentation of green fodder. For residue estimation from green fodder, representative samples of maize fodder were collected at 60 DAS and at harvest. The sample of spring maize silage was collected from silage made in low density polypropylene bags. Total weed density and biomass at 60 DAS was significantly lower with atrazine 1.0 kg/ha PE as compared to unweeded control in all the three cropping systems. The dry fodder yield of spring maize was higher under maize-oat-spring maize and maize-toria-spring maize cropping systems.In maize-oat-spring maize and maize-toria-spring maize cropping systems, atrazine residue to the tune of 0.01 mg/ kg was observed in green fodder samples of spring maize at 60 DAS. However, atrazine residue was below limit of quantification (<0.01 mg/kg) in maize-gobhi sarson-spring maize cropping system. Further, atrazine residue is below the limit of quantification in maize fodder and its silage at harvest under all three cropping systems. Therefore, atrazine 1.0 kg/ha PE in spring maize grown for silage making is safe for milch animals.

Residue status of pre-emergence application of pendimethalin in cumin and soil of Bhal region of middle Gujarat

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Pendimethalin is a broad spectrum, selective pre-emergence and pre-plant incorporation herbicide recommended in soybean, cotton and chilli for effective control of different weed species. Presently, this herbicide is registered for controlling the weeds species of soybean, cotton and chilli by Indian regulator with waiting period of 41, 101 and 98 days, respectively. Day to day the label claim expansion in different crops is still continuous inevitable process for future food security of the country. Therefore, to generate the data on residue of pendimethalin in cumin and soil a field experiment was conducted using randomized block design with adopting all agronomical practices during *Rabi* 2018 at Agricultural Research Station, Anand Agricultural University, Arnej under Bhal region of middle Gujarat. Soil of Bhal region is clay. Cumin variety '*Gujarat cumin-4*' was sown for field experiment. Pre-emergence application (PE) of pendimethalin 38.7% CS at recommended dose (677.25 g/ha) and double the recommended dose (1354.50 g/ha) were applied by using knap-sack sprayer fitted with flood jet nozzle. Gas Chromotography with electron captured detector; make; Thermo Trace-1310 with TG-5 sil MS column, thicknesss:0.25 mm, length:30 m, diameter:0.25 mm was used for analysis of the pendimethalin. For recovery study, untreated cumin plant, cumin seed and soil samples were fortified at 0.05, 0.25 and 0.50 µg/g with five repetitions. Linearity was assessed through the coefficient of determination (R^2) derived from eight-point calibration curve. Mean recovery of pendimethalin were 102.19, 99.97 and 99.25% for cumin plant, 91.68, 87.18 and 92.41% for cumin seed and 82.26, 84.71 and 83.02% for soil, respectively which was in conformity with SANTE guidelines, 2017 (Ranged 70-120%). Samples of cumin plant were collected 20, 25, 30 and 35 days after pendimethalin application. Below determination limit was 0.05 µg/g. Quick, easy, cheap, effective, rugged and safe (QuEChERS) method was use for determination of residue of pendimethalin from substrate by using the acetonitrile, partitioned with magnesium sulphate. Residue of pendimethalin at standard and double dose were 0.06 and 0.07 µg/g after 20 days after application (DAA). Residue of tested chemical was below detectable level (*i.e.* 0.05 µg/g) after 25, 30, 35 DAA in cumin plant. Residue of pendimethalin was also found below detectable level in cumin seed and clay soil at harvest stage (*i.e.* 119 days after application). It can be concluded that cumin seed is safe for human consumption and pendimethalin do not remain in soil ecosystem after 119 DAA. Waiting period 119 days suggested for pendimethalin pre-emergence application in cumin.

Weed management under organic production system of rice-vegetable pea-sweet corn cropping system

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The rice based cropping system in India is prominent cropping system among all cropping systems. The recent emphasis in agriculture has shifted from a primary goal of maximizing yields over the short term, to a sustainable productivity over long periods of time. The growing concern for human health and sustainability of agricultural production is giving way for organic farming. Weeds are often recognized as the most serious threat to organic crop production and fear of ineffective weed control is often perceived by farmers as one of the major obstacles to conversion from conventional to organic farming. Organic systems also requires the use of preventive methods before growing the crop and to establish a reasonable crop rotation. Stale seed bed preparation is a very good option to delay the start of weed competition. Use of cover crops and green manure may help to control some weed species. Most common methods used to prevent weed competition in organically grown crops are high seeding rates, narrow seed spacing/cross seeding, and companion cropping with small-seeded legumes. An experiment was initiated during *Kharif* 2020 at N.E. Borlaug Crop Research Centre, G.B.P.U.A&T, Pantnagar with split plot design and three replications. The main plot consisted of four treatments, stale seed bed-direct-seeded rice + *Sesbania*; direct-seeded rice (without stale seed bed); *Sesbania* (GM)-transplanted rice and transplanted rice, in all the treatments vegetable pea was taken in *Rabi* season and sweet corn during spring season. Sub plot treatment consisted of three treatments, mechanical weeding (two passes of conoweeder); mechanical weeding (one pass of conoweeder followed by (*fb*) one hand weeding (HW) and mechanical weeding (by hoe) and hand weeding twice at 25 and 45 DAS/DAT. One hand weeding was done at 45 days after sowing or transplanting (DAT) in case of rice, whereas in case of vegetable pea and corn it was done on 30 days after sowing (DAS). The highest grain yields of rice (3.1 t/ha) and vegetable pea (8.4 t/ha) were achieved with stale seed bed-direct-seeded rice along with *Sesbania* (M1), whereas, all the establishment system attained similar cob yields of sweet corn (7.6 t/ha) except transplanted rice (M4).Among non-chemical weed management practices, mechanical weeding with one pass of conoweeder *fb* one hand weeding (S2) recorded highest grain yield of rice (2.9 t/ha),while, mechanical weeding with two pass of conoweeder (S1) recorded highest vegetable pea pod yield (8.3 t/ha) and cob yield of corn (7.6 t/ha).

Mulch based weed management strategies in organic baby corn-cabbage cropping system

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Organic farming especially of vegetables is gaining momentum across the world owing to growing awareness of health and environment issues. The domestic and international market for organic products is growing around 20-25% annually. Weed management is important constraint in organic farming. The annual loss of agricultural products in India because of weeds is over US$ 11 billion. In particular, weeds in vegetable crops can cause 100% yield loss, especially in organic farming. Hand weeding (HW) and mechanical weeding (MW) have become costly and sole dependence on them is not practicable. Hence, development of effective and economical weed management strategy would help the organic growers to maximize the profits apart from keeping the weed pressure under control. Organic vegetables are preferred in major urban centers in India. Baby corn- cabbage organic cropping system provides good profits to the peri-urban farmers. In view of the above, an experiment was conducted on an eight-year-old organic site at AICRP centre on Weed Management, PJTSAU, Hyderabad during 2020-21 and 2021-22, to investigate the efficacy and economics of the non-chemical and mulch-based weed management methods integrated with HW in a randomized block design. The treatments in *Kharif* baby corn comprised of live mulch with *dhaincha (Sesbania aculeata)*, stale seed bed + HW twice, poly film mulch + HW, rice straw mulch + HW, MW twice + HW, intercropping leafy vegetable + HW and unweeded check (UWC). Correspondingly, groundnut shell mulch, rice husk mulch, poly film mulch + HW, rice straw mulch + HW, MW twice +HW, intercropping leafy vegetable and UWC were tested in *Rabi* cabbage. Higher yield of baby corn along with efficient weed control was observed in inter-row poly-film mulching (30 microns) + intra-row HW at 30 days after seeding (DAS) (3.07 t/ ha) or stale seed bed + HW at 20 and 40 DAS (2.80 t/ ha) or rice straw mulch 5 t/ha + intra row HW at 30 DAS (2.78 t/ha). During *Rabi* season, mulching with groundnut shells 2 t/ha resulted in higher cabbage yield (37.16 t/ha) followed by poly film mulch + intra row HW at 30 DAT (30.07 t/ha) and rice straw mulch 5 t/ha + intra-row weeding at 30 DAT (28.47 t/ha) apart from effective weed suppression. However, the cropping system productivity *i.e.,* baby corn equivalent yield (16.92 t/ ha), net returns (₹ 612,502/-) and B:C ratio (3.57) were highest in the combination of live mulching with dhaincha upto 30 DAS in baby corn and groundnut shell mulching 2 t/ha in cabbage followed by poly film mulch+ intra row HW at 30 DAS/T in both the crops (15.10 t/ha, ₹ 465,953/- and 2.58, respectively) or rice straw mulch5 t/ha + intra row HW at 30 DAS/T in both the crops (14.17 t/ha, ₹ 465,339/- and 2.87, respectively). Thus, it can be concluded that mulch-based weed management strategies not only reduce the weed pressure but also maximize the profits for organic vegetable growers.

Weed management in soybean-gram sequence in organic production under irrigated condition

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Weeds are the most serious threat to agricultural production in India. Weeds are widely reported as key constraint in organic agriculture. Soybean-gram is important cropping sequence adopted in Maharashtra State under irrigated condition. Today widespread use of herbicides has resulted in purporated environmental and health problem as well as residual problem to succeeding crop. Currently, residue free food requirement is high. In organic farming cultural and mechanical methods are necessary to break the weed cycle. Hence, a study was carried out on weed management in soybean-gram sequence in organic production under irrigated condition. A field experiment was conducted at experimental farm of AICRP on Integrate Farming System, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) during *Kharif* and *Rabi* seasons of 2017-18 and 2018-19. The present study consisted of ten weed management treatments *viz,* T1 - hand weeding twice at 20-25 and 45-50 days after seeding (DAS), one hoeing 20-25 DAS + one hand weeding at 45-50 DAS, soybean + sunhemp incorporation after 35-40 DAS in *Kharif* and gram + safflower (2:1) in *Rabi* season, stale seed bed + reduced spacing + 2 tonne of wheat straw + one hand weeding at 25 DAS, soil mulch at the time of sowing + one hand pulling at 25 DAS, incorporation of neem cake 1.5 t/ ha 15 days before sowing + one hand weeding at 25 DAS, soil solarization with 25 µ polythene mulch during summer + one hand weeding at 25 DAS, mulching with straw, weed free and weedy check. The predominant weed flora in soybean were: *Cynodon dactylon, Brachiaria eruciformis, Commelina benghalensis, Cyperus rotundus, Phyllanthus niruri, Parthenium hysterophorus* and *Euphorbia geniculata*. The predominant weed flora in gram were C*ynodon dactylon, Cyperus rotundus, Phyllanthus niruri*, *Convolvulus arvensis* and *Amaranthus viridis*. During both the years, significantly higher soybean equivalent yield of system (25.07) and maximum system productivity (26.18) and lower weed index was recorded by stale seed bed + reduced spacing (30 cm) + mulching with wheat straw (2 t/ha) + one HW at 25 DAS which was at par with soybean + sunhemp incorporation after 35-40 DAS in *Kharif* and gram + safflower in *Rabi* season. Soybean + sunhemp incorporation after 35-40 DAS in *Kharif* and gram + safflower (2:1) in *Rabi* season recorded significantly higher net returns of system (₹ 95257/ha) and higher system profitability (₹ 261 ha-1 day-1) and which was at par with stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS (₹ 80668/ha) and system profitability(₹ 221ha-1 day-1) and significantly superior over rest of the treatments during both the years.

Evaluation of phyto-extracts for weed management in sweet corn under organic production

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In the present-day context, organic sweet corn is assuming greater importance due to its chemical free nature and has a big market potential. Weed menace is one of the major challenges under organic production system. Therefore, a field experiment was conducted at All India Network Programme on Organic Farming (NPOF) unit at University of Agricultural Sciences, Dharwad (Karnataka) on *vertisols* with medium soil fertility during *Kharif* 2020 and 2021 to find out suitable phyto-extracts for weed management in sweet corn under organic production system. The experiment was laid out in randomized complete block design with three replications. The treatment comprises of 15 treatments, v*iz*. 4 phyto extracts of 30% concentration (*Parthenium hysterophorus, Cassia sericea, Lantana camara* and *Prosopis juliflora)* in combinations with foliar spray of respective extract at pre-emergence, 20 days after sowing (DAS), 40 DAS and one inter cultivation (IC) at 40 DAS *fb* hand weeding and T_{13}- inter cultivation at 20 and 40 DAS followed by (*fb*) one hand weeding at 20 DAS, T_{14}-weedy check, T_{15}-weed free check. The pooled data indicated that foliar spray of *Parthenium hysterophorus* 30% leaf extract at 20 DAS and one IC at 40 DAS *fb* hand weeding recorded significantly higher fresh cob yield (15.9 t/ha) and fresh fodder yield (31.5 t/ha) of sweet corn. At 60 DAS, significantly lower total grassy, broad-leaved weeds, and sedges density (2.61, 3.43 and 1.89/m^2 respectively.), total weed biomass (5.66 g/m^2) and higher weed control efficiency (80.40%) were observed with foliar spray of *P. hysterophorus* 30% leaf extract at 20 DAS and one IC at 40 DAS *fb* hand weeding. Significantly higher plant height (144.69 cm), number of leaves (10.64) and total dry matter accumulation of crop (92.68 g/plant) was also observed with foliar spray of *P. hysterophorus* 30% leaf extract at 20 DAS and one IC at 40 DAS *fb* hand weeding. Dehydrogenase activity at 45 das showed non-significant results with respect to the different phytoextracts used in this experiment. Compared to weed free check, lower reduction in the yield was observed with foliar spray of *P. hysterophorus* at 30% leaf extract at 20 DAS and one IC at 40 DAS *fb* hand weeding (22.40%). Higher fresh cob yield loss (41.42%) was noticed under weedy check. Different treatments showed non-significant influence on quality parameters like total soluble solids and total sugars. Foliar spray of *P. hysterophorus* 30% leaf extract at 20 DAS and one IC at 40 DAS *fb* hand weeding recorded significantly higher gross returns (₹ 2,54,400/ha), net returns (₹ 1,89,405/ha) and B:C ratio. The available N, P and K in soil, recorded after harvesting of the crop, were higher under foliar spray of *P. hysterophorus* 30% leaf extract at 20 DAS and one IC at 40 DAS *fb* hand weeding.

Mycobiota associated with the weed water hyacinth (*Pontederia crassipes*) in Kolkata, India, with prominence on biological control of the macrophyte

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The massive infestation of the aquatic macrophyte, water hyacinth, (*Pontederia crassipes*) Mart. (Pontederiaceae) and its negative impact on the global socio-economic conditions have made it one of the top ten invasive weeds of the world. The global rise in temperature, due to climatic changes, has facilitated the spread of this monocotyledonous macrophyte asexually using stolons and also sexually by seeds with a rapid reproductive capacity that enables it to double its biomass in 6–14 days. To restrict the infestation, different control measures have been implemented. The laborious and slow process of the manual and mechanical approaches against the high propagation rates of the weed and the environmental degradation with the use of chemical herbicides, along with the threat of herbicide-resistant weeds, have ushered in an increase in the use of biocontrol agents against the weed. Apart from some of the most established arthropods, like *Neochetina bruchi* (Hustache), *N. eichhorniae* (Warner) (Coleoptera: Curculionidae) and *Orthogalumna terebrantis* Wallwork (Acarina: Galumnidae), against water hyacinth, several plant pathogens have shown significant damage control potential. With a limited number of arthropod agents, the plethora of phytopathogens has proven to be very promising against the macrophyte. This has led to an extensive systematic survey of water bodies in and around Kolkata, India, between 2014-2019 to assess the natural occurrence of various indigenous and potent phytopathogenic fungi against the weed. The frequency of pathogens was also observed along with identification using morphological and molecular techniques. The continual survey brought into light several fungal species with some first reports of naturally occurring native phytopathogenic fungi and their evolutionary-related lineages. It reduces the stress on limited species and broadens the list of agents against this weed, apart from some of the most commonly used microbial biocontrol agents like various species of *Alternaria, Acremonium, Fusarium, etc*. Around 150 fungal pathogens (isolated from water hyacinth) were evaluated for their disease-causing potential against the weed. *Fusarium* Link, followed by *Alternaria* Nees, was the highest and most consistently isolated genera. Seven potential fungi that caused more than 90% of disease symptoms on the weed were subjected to host range evaluation against 67 economically important plant species also belonging to the same ecological niche. Among these, *Fusarium oxysporum* f. sp. *lycopersici* was found to have a narrow host range and be effective against the weed. With further studies on their impact assessment, environmental viability, and tolerance, few of them, like *F. oxysporum,* could effectively reduce population growth of water hyacinth by themselves or in conjunction with other introduced biocontrol agents, including insects and plant pathogens. With increasing development and application of xenobiotic compounds, such as chemical pesticides, exercising eco-friendly biological control methods becomes an absolute necessity to control aquatic weeds without bioaccumulation or leaving a negative impact on the ecosystem. With the array of mycobiota used against waterhyacinth, most have indicated unsuitability as a biocontrol agent from pathogenicity and host-range trials, which could be due to either poor sporulation or low dispersal that requires mostly repeated applying rather than one-time application to ensure a sustainable control. A proper insight into the host range test with safety assessment on non-target plants and other potential biocontrol agents has to be widened before being applied as a potent bioherbicide in the field.

Weed dynamics, weed control efficiency, yield attributes and yields of chickpea in response to pre- and post-emergence application of herbicides

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Bundelkhand region of Uttar Pradesh (UP), India is a major pulse producer in the Indian subcontinent. The pulse productions is playing a significant role in strengthening the economic conditions and are the source of livelihood of the region. The productivity of chickpea in the region is low due to various biotic and abiotic stresses. Among the various biotic stresses, weeds are the major ones which causes severe yield loss in pulses. A field experiment was conducted at research farm of College of Agriculture, BUAT, Banda, Uttar Pradesh during *Rabi* season of 2020-21 and 2021-22. The experiment was laid out using randomized block design (RBD) with thirteen treatments and three replications. The recommended package of practices were used. Before seeding the seeds were treated with liquid rhizobium culture at the rate of 10 ml/kg seed. The spray of herbicide was done as per treatments with the help of knap-sack sprayer fitted with flat-fan nozzle. The weed density, weeds biomass, crop growth parameter, yield attributes and yield of crop were recorded as per standard protocols. Economic analysis was done by following the methods suggested by DWR, Jabalpur. The weed density and biomass were analyzed after transforming the actual data (X) to square root of (x+1). The experimental field of chickpea was infested with several broad-leaved, grassy and sedge weeds. The major weed species were: *Cyperus rotundus, Digera arvensis, Chenopodium album, Anagalis arvensis, Spergula arvensis, Launaea asplenifolia, Cynodon dactylon etc*. Amongst dominant weedsseveral kinds of weeds *Cyperus rotundus* was observed as predominant weed with more than 80% relative density. Weed density reduced significantly with post-emergence application (PoE) of imazethapyr 40 g alone or after pre-emergence application (PE) of either pendimethaline or oxyfluorfen. Lowest weed biomass (8.0g/m^2 and 9.2 g/m^2 at 90 DAS during both the years) was recorded with pendimethaline 1000 g PE followed by (*fb*) imazethapyr 40 g PoE. The highest weed control efficiency (WCE) (75.9% and 70.3%) was associated with pendimethaline 1000 g PE *fb* imazethapyr 40 g PoE, which was equivalent to highest WCE recorded with weed free treatment. With advancement of crop stage weed control efficiency reduced probably due to reduced weed management efficacy of herbicides. Minimum reduction in grain yield (3-4%) was observed with pendimethaline 1000g PE *fb* imazethapyr 40g PoE and Oxyfluorfen 100 g PE *fb* imazethapyr 40 g PoE. Effect of weed management practices exert marked effect on yield attributing traits and yields. Among testedweed control treatments, maximum value of yield attributes were associated with pendimethaline 1000 g PE *fb* imazethapyr 40 g PoE. Highest grain yield (1.61 and 1.90 t/ha) and straw yield (1.88 and 2.10 t/ha) and highest net returns during both the years were obtained when weeds managed with pendimethaline 1000g PE *fb* imazethapyr 40 g PoE.

Post-emergence herbicides for weed management in greengram

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India is the highest producer as well as consumer of pulses in the world. Pulses play a vital role in Indian Agriculture. In India, total production of green gram is 2.05 million tons. Green gram is the third important pulse crop of India grown in nearly 8% of the total pulse area of the country. Its seed contains 24.7% protein and serves as cheaper protein source. Since using herbicides has a minimal operational cost and is not labor intensive, it provides an effective and economical control of weeds. A field experiment was conducted, at G.B.Pant University Agriculture and Technology, Pantnagar during *Kharif* season of 2017 and 2018, to evaluate the bio-efficacy of fomesafen 11.1% w/w + fluazifop-p-butyl 11.1% w/w SL for control of complex weed flora in green gram and its residual effect on succeeding crop. The experiment was laid out in randomized block design having three replications. All the herbicides alone or in combination were applied at 20 days after sowing (DAS) with knapsack sprayer fitted with flat-fan nozzle using 500 litre water/ha. The experiment comprised of treatments, *viz*. post-emergence application (PoE) of three doses of fomesafen + fluazifop-p-butyl 25% SL at 187.5, 250 and 312.5 g/ha, fomesafen 156.25 g/ha, fluazifop-p-butyl 156.25 g/ha, quizalofop-ethyl 50 g/ha and propaquizafop 100 g/ha and hand weeding twice at 20 and 40 days after seeding (DAS). The major weed flora recorded in weedy check plots in green gram crop consisted of: *Eleusine indica*, *Echinochola colona, Digitaria sanguinalis, Dactyloctenium aegyptum* and *Panicum maximum* among grassy weeds. Among non-grassy weeds *Mollugo stricta*, *Celosia argentia*, *Phyllanthus niruri*, *Eclipta alba, Digera arvensis* and *Amaranthus viridis* were observed whereas, among sedges *Cyperus rotundus* and *Cyperus iria* were the predominant weeds. The fomesafen + fluazifop-p-butyl 25% SL applied at 250 and 312.5 g/ha PoE were found to be most effective in controlling all type of weeds in green gram crop and these doses were at par with each other. Progressive increase in doses of fomesafen + fluazifop-p-butyl from 187.5 to 312.5 g/ha resulted in reduced weed density and dry biomass of all the weed species. Propaquizafop 100 g/ha and quizalofop-ethyl 50 g/ha were standard checks. There were no phytotoxic symptoms observed due to any dose of fomesafen + fluazifop-p-butyl 25% SL. The highest grain yield (1.30 t/ha) was obtained with fomesafen + fluazifop-p-butyl 25% SL at 312.5 g/ha followed by hand weeding twice at 20 and 40 DAS (1.21 t/ha). At 21 and 42 days after application, the ready-mix application of fomesafen + fluazifop-p-butyl 25% SL 312.5 g/ha recorded higher weed control efficiency (WCE) (97.2 and 96.0) and herbicide efficiency index (HEI) (16.83 and 13.26), respectively.

Response of weed dynamics, growth and yield of greengram to different post-emergence herbicides

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Weeds are the key factor that adversely affect the growth, quality and yield of mungbean during growing season. Being a short duration crop, it faces strong weed competition from the early growth stages to harvesting. Weed flora in the experimental field consisted of grassy weeds: *Cynodon dactylon*, *Dactyloctenium aegyptium* and *Eragrostis minor*; broad-leaved weeds: *Amaranthus viridis*, *Celosia argentea*, *Chorchorus trilocularis*, *Digera arvensis*, *Phyllanthus niruri*, *Portulaca oleracea* and *Tribulus terristris*. However, broad-leaved weeds were dominant over grassy and sedge weeds. The critical period of crop weed competition in mungbean was initial 25–30 days, yield may reduce up to significant level if weeds are not managed at this stage. Hence, it is essential to find out the best weed management strategies to obtain higher productivity and profitability. Therefore, a field experiment was conducted at Agricultural Research Station, Mandor to assess the effect of different post-emergence herbicides in mungbean during the *Kharif* season of 2021-22 to observe the better weed management practice under arid climatic conditions. The experiment was laid out in random block design with eight treatments replicated thrice. The treatments comprised post-emergence herbicides along with hand-weeding at 20 and 40 days after seeding (DAS), weed-free, and unweeded plot. The results revealed that all the herbicidal treatments significantly reduced weed density and weed biomass at 30 and 45 DAS over the unweeded control plot. The highest weed control efficiency (WCE) (%) was recorded with weed free treatment followed by (*fb*) manual weeding twice at 20 and 40 DAS treatment (90.5%) and fomesafen + fluzifop-p-butyl 220 g/ha at 20 DAS (ready-mix) as post-emergence (76.5%). All herbicidal treatments significantly increased number of branches/plant, pods/plant, seeds/pod, seed yield and biological yield of mungbean crop over unweeded plot. Application of fomesafen + fluzifop-p-butyl 220 g/ha at 20 DAS (ready-mix) as post-emergence was recorded statistically significant over the unweeded control and fluzifop-p-butyl 250 g/ha 20 DAS as post-emergence in growth and yield parameters. However, it was at par with other weed management treatments. No statistically significant difference was observed in harvest index between all weed management treatments. The highest net returns and BC ratio were obtained in the treatment fomesafen + fluzifop-p-butyl 220 g/ha at 20 DAS (ready-mix) as post-emergence application *fb* propaquizafop 33.3 g + imazethapyr 50 g/ha at 20 DAS (ready-mix). It can be concluded that application of fomesafen + fluzifop-p-butyl 220 g/ha at 20 DAS in mungbean crop is effective for management of weeds and higher production and profitability from greengram crop under the soil and agro climatic conditions of western Rajasthan.

Effect of integrated weed management on weed dynamics in blackgram

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A field experiment was conducted during the *Rabi* season of 2020-21 in Kurnool district of Andhra Pradesh in a farmers's field to access the efficacy of integrated weed management on weed dynamics in blackgram (*Vigna mungo* L.). The experiment was laid out in randomized block design with three replications comprising ten treatments, *viz.* weedy check, pendimethalin 1.0 kg/ha as pre-emergence application (PE), oxyfluorfen 0.18 kg/ha PE, imazethapyr 50 g/ha post-emergence application (PoE) at 25 DAS, pendimethalin 1.0 kg/ha PE + one hand weeding at 30 days after seeding (DAS), oxyfluorfen 0.18 kg/ha PE followed by (*fb*) one hand weeding at 30 DAS, pendimethalin 1.0 kg/ha PE *fb* imazethapyr 50 g/ha PoE at 25 DAS, oxyfluorfen 0.18 kg/ha PE *fb* imazethapyr 50 g/ha PoE at 25 DAS, hand weeding at 30 DAS, hand weeding twice at 20 and 40 DAS. The lower values of weed density, weed biomass and higher weed control efficiency (WCE) were recorded with the treatment hand weeding twice at 20 and 40 DAS irrespective of the weed species and stage of the crop, and it was comparable with the treatment pendimethalin 1.0 kg/ha PE *fb* imazethapyr 50 g/ha PoE at 25 DAS. The higher values of weed density, weed biomass and lower weed control efficiency (WCE) were registered with the treatment weedy check. Among the weed management practices tested, hand weeding twice at 20 and 40 DAS and pendimethalin 1.0 kg/ha PE *fb* imazethapyr 50 g/ha PoE 25 DAS resulted in the higher growth parameters, *viz.* plant height, number of branches per plant, number of leaves per plant, leaf area index (LAI), crop growth rate (CGR) and relative growth rate. The lowest values of growth parameters were registered with the treatment weedy check. A similar trend also followed for the yield attributes and yield, *viz.* number of pods per plant, length of pods, number of seeds/pod, test weight, grain yield, stover yield and harvest index. The higher gross returns were recorded with hand weeding twice at 20 and 40 DAS which in turn was statistically comparable with the treatment pendimethalin 1.0 kg/ha PE *fb* imazethapyr 50 g/ha PoE at 25 DAS. However, the higher values of net returns and benefit-cost ratio were registered with pendimethalin 1.0 kg/ha PE *fb* imazethapyr 50 g/ha PoE at 25 DAS which was on par with oxyfluorfen 0.18 kg/ha PE *fb* imazethapyr 50 g/ha PoE at 25 DAS.

Weed management in pigeonpea + greengram intercropping system

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Intercropping has become a popular practice with the farmers, as it acts as means of insurance in the event of unfavourable conditions. Suitable intercropping system may increase the total production through efficient utilization of production factors. Weed control in intercropping is important as in sole cropping since weeds are additional competitors for resources in an already strained system. Pigeonpea + greengram intercropping system is prevalent on semi-arid tropic areas, as it is advantageous because greengram being a short duration crop utilizes resources effectively during early season and pigeonpea being a long duration with slow initial growth, can utilize the resources during later period, so the competition between two crops does not exist. Manual weeding is difficult due to continuous rains and increased cost of operation and scarcity of labour. Hence, there is a need to adopt an alternative and appropriate method of weed management practices particularly during early stage of crop growth. Herbicides are often crop specific. Herbicides recommended for sole crops are not suitable for intercropping due to the differential nature of crops. The less weed growth under intercropping due to weeds smothering necessitates lesser doses of herbicides. Similarly weed spectrum is also changes under intercropping when compared to sole crop, which requires a change in herbicide and its dosage. Technical considerations also severely restrict the herbicide utilization in intercropping. So, it will be advantageous to the farmers, if a herbicide with selectivity to both the component crops is identified. With this background, a field experiment was conducted to study the weed management in pigeonpea [*Cajanus cajan* (L.) Millsp.] + greengram [*Vigna radiata*] intercropping system at MARS Farm, UAS Raichur during *Kharif* 2018-19 on clay loam soil. The experiment was laid out in randomized complete block design comprising of ten different weed management treatments. The pre-emergence application (PE) of pendimethalin 750 g/ ha followed by (*fb*) imazethapyr 75 g/ ha at 3-4 leaves stage of weeds *fb* IC at 40 days after seeding (DAS) recorded lower weed index (3.21 and 14.27 in pigeonpea and greengram, respectively) and higher weed control efficiency (78.09%) at 60 DAS as compared to weedy check. Nevertheless, one hand weeding at 20 DAS *fb* two intercultivations at 40 and 60 DAS accounted for lower weed index and higher weed control efficiency. Pendimethalin 750 g/ ha PE *fb* imazethapyr 75 g/ ha at 3-4 leaves stage of weeds *fb* IC at 40 DAS recorded significantly higher seed yield of pigeonpea (1266 kg/ ha) and greengram (907 kg/ ha) and pigeonpea equivalent yield (2536 kg/ha). Nevertheless, one hand weeding at 20 DAS *fb* two intercultivations at 40 and 60 DAS recorded significantly higher net returns (₹ 94,970/ ha) and B:C ratio (4.30) followed by pendimethalin 750 g/ha PE *fb* imazethapyr 75 g/ha at 3-4 leaves stage of weeds *fb* IC at 40 DAS (₹ 85,152 /ha net returns and 4.07 B:C ratio).

Weed management for major *Rabi* crops of saurashtra Region-Gujarat

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In Gujarat, many *Rabi* crops are grown, *viz.* wheat, chickpea, maize, cumin, fenugreek, coriander, fennel, onion, garlic etc. However, among them, the major area is under wheat, chickpea and coriander crops particularly in South *Saurashtra* region. Wheat is infested by multifarious weed flora comprising both grassy as well as broad-leaf weeds causing yield reduction of 15-40% depending upon type and intensity of their infestation. Chickpea, however, is poor competitor to weeds because of slow growth rate and limited leaf area development at early stages of crop growth (30-45 DAS). As coriander is low water requiring, remunerative and short duration crop, farmers of Saurashtra region are attracted towards its cultivation in *Rabi* season. Heavy weed growth appears to be the most serious menace in realizing the full yield potential of coriander. Crop-weed competition reduces the seed yield of coriander by 72.8 to 74.6%.Weed emergence with the *Rabi* sown wheat, chickpea and coriander crops creates a severe competition unless controlled timely and effectively. Inter-row cultivation is not sufficient and hand weeding is necessary under most conditions. Therefore, there is an urgent need to move from the costly manual/mechanical weed control to chemical weed control. Hence, identification and use of a selective and cost effective herbicide alone or in combination with hand weeding in an integrated manner can be a good alternative for effective weed management. Keeping these facts in view, the experiments were conducted to test the bio-efficacy herbicides for weed management in wheat, chickpea and coriander.Three separate field experiments were coducted during *Rabi* seasons at Junagadh (Gujarat) to evaluate efficacy of herbicides comprising of various treatments for wheat with twelve treatments, for chickpea with twelve treatments and for coriander ten treatments, which were laid out in randomized block design with three replications. The herbicide spray was done using knapsack sprayer with flood-jet nozzle with spray volume of herbicide 500 L/ha.Among the different treatments in different crops, effective weed management along with higher yield and net returns from *Rabi* wheat was achieved by HW at 15 DAS *fb* either pre-mix sulfosulfuron + metsulfuron 32 g/ha or pre-mix clodinafop + metsulfuron 64 g/ha at 30 DAS or HW at 15 and 30 DAS as per availability of labourers. Efective weed management along with higher seed yield of chickpea and net return was achieved by application of pendimethalin 750 g/ha as pre-emergence *fb* IC and HW at 30 DAS or pre-mix pendimethalin + imazethapyr 750 g/ha as pre-emergence *fb* IC and HW at 30 DAS,and effective weed management along with higher seed yield of coriander was achieved by application of tank-mix pendimethalin 450 g/ha + oxadiargyl 30 g/ha as pre-emergence *fb* HW at 30 DAS or paraquat 500 g/ha as early post-emergence at 7 DAS *fb* HW at 30 DAS or pendimethalin 750 g/ha as pre-emergence *fb* HW at 30 DAS.

Weed management in direct-seeded rice

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The main bottleneck for the successful adoption of direct-seeded rice (DSR) is the weed problem. DSR experiences severe crop – weed competition during its initial growth stages which is detrimental for its higher productivity. Farmers at present are in need of effective post-emergence herbicide in direct-seeded rice which is convenient for them to apply depending upon the intensity of weeds (window of application) and it also reduces the dependence on manual labor for weeding under present labor scarce conditions. Hence, experiments were conducted at University of Agricultural Sciences, Hebbal, Bengaluru, Karnataka during 2018-19 and 2019-20 in RCBD involving nine treatments replicated thrice to observe the efficacy of new herbicides against sedges, broad-leaved and grassy weeds in DSR, its phytotoxicity and effect on succeeding crop. Major weed flora observed in experimental field were: *Cyperus rotundus* (sedge); *Cynodon dactylon*, *Dactyloctanium aegyptium*, *Digitaria marginata*, *Eleusine indica* and *Echinochloa colona* among grasses and *Borreria articularis, Commelina benghalensis, Alternanthera sessilis, Acanthospermum hispidium, Euphorbia hirta, Amaranthus viridis, Celosia argentea* among broad-leaved weeds. The treatments consisted of: pre-emergence application (PE) at 3 days after seeding (DAS) of bensulfuron methyl + pretilachlor 660 g/ha and pendimethalin 750 g/ha) and post–emergence application (PoE) at 15 DAS of carfentrazone 25 g/ha, ethoxysulfuron 15 g/ha, penoxsulam + cyhalofop 135 g/ha, bispyribac sodium 20 g/ha and triafamone + ethoxysulfuron 60 g/ha) in comparison to passing cycle weeder and hand weeding twice at 20 and 35 DAS and weedy check. In case of herbicide applied treatments, passing of cycle weeder and hand weeding have also been undertaken once at 30 DAS. Pooled data of two years indicated that triafamone + ethoxysulfuron 60 g /ha at 15 DAS followed by (*fb*) cycle weeder and hand weeding at 30 DAS recorded significantly higher grain yield (5402 kg/ha) with highest B:C ratio (1 : 2.54) and lowest weed index (2.6 %) compared to all other herbicidal treatments but was on par with passing cycle weeder and hand weeding at 20 and 35 DAS (5548 kg/ha with B:C ratio 1 :2.36). Black gram was taken as succeeding crop after direct-seeded rice and the herbicides applied in direct-seeded rice did not show any phytotoxicity to blackgram.

Managing weeds with competitive varieties in upland direct-seeded autumn rice in Assam

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The area and production of upland direct-seeded (DS) autumn rice decreased significantly in Assam from 0.35 million hectare and 3.48 mt to 0.19 mha and 2.58 mt during 2007-08 to 2015-16, respectively, mostly because of the weed problem. To mitigate this problem experiments were conducted to screen-out rice varieties with better weed suppressing ability (WSA) as-well-as to determine the critical period of crop-weed competition (CPCWC). Out of ten rice varieties tested during 2015 and 2016, var. '*Rongkhang'* and '*Inglongkiri'*, the recommended varieties for hills, were selected to test for the plains. Another experiment was conducted during 2017-19 by following Neoto model to determine CPCWC. Crop was sown by practicing the recommended package of practices in the third week of February and harvested in June and as per the treatments, weeds were eradicated manually. The rhizomatous grass *Panicum repens* with thorny broad-leaved *Mimosa pudica* became rather predominant in upland crop-fields in Assam. Seed-borne *Eleusine indica, Mimosa pudica, Ageratum* and Spermacoce species were the early emerged weeds along with *Cynodon dactylon*, within the first 20 days-after-sowing (DAS). *Digitaria setigera, Panicum repens, Fimbristylis* spp. *etc*. became prominent at around 30 DAS; whereas, *Acmella ciliata, Crassocephalum crepedioides, Commelina* spp. and *Murdania nudiflora*, along with grasses like *Setaria pumila* and *Paspalum conjugatum* appeared during 30 to 60 DAS. The most troublesome sedge *Scleria terrestris* and broad-leaved *Melochia corchorifolia* became prominent after 40 DAS. Weed biomass was nearly 2 g/m^2 at 10 DAS and 10-12 g/m^2 at 20 DAS. The weed growth was rather active between 20 to 40 DAS, and then slowed down between 40 to 50 DAS; at 50 DAS the weed dry matter varied between 47 to 52 g/m^2. The crop stature was above 110 cm in the varieties Inglongkiri, Rongkhang and Maizubairon. The stature of *Disang, Kolong and Kopili* varied from 37 to 53 cm, and that of *Meghi, Guni, Haacha* and *Sahbhagi* varied from 67 to 89 cm. Variety Maizubairon produced the highest Leaf-area-index (LAI=20.01), which was at par with var. *Inglongkiri* and *Guni*; var. *Disang* and *Kolong* produced the least. LAI between weedy and weed free treatments did not differ significantly. Leaves were somewhat spreading in var. *Guni*, *Inglongkiri, Meghi* and *Disang*; their leaf angle with the culm varied from 51.8^o to 37.9^o. In contrary, var. *Sahbhagi* (17^o), *Kolong* (22.5^o), *Maizubairon* (24^o), *Rongkhang* (30.8^o) and *Kopili* (30^o) had erect type of leaves. The flag leaf angle was the highest in var. Meghi (102.5^o) *fb* var. *Inglongkiri* (89.9^o). The crop growth pattern revealed that increase in competition has slowed down the active growth phase which might have skipped for 15 to 30 days. The average grain yield varied from 1t/ha to 1.88 t/ha in Rongkhang, which performed better than variety Inglongkiri (1.82 t/ha). The average yield was the maximum in the treatments where the weeds were allowed to compete up to 20 days after seeding (DAS). In the set of treatments where weeding was done in early part of crop growth and kept weedy after that, the maximum average yield was recorded in the treatment where crop kept weed free up to 40 DAS in both the years. These results distinctly conferred that the CPCWP for the upland direct-seeded rice variety Rongkhang and Inglongkiri as 20 to 40 DAS. They showed 28 to 57% WSA over the other tested varieties.

Impact of tillage and weed management options on soil quality in rice-maize-*Sesbania* cropping system under conservation agriculture

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A six-year field experiment was conducted at AICRP on Weed Management, College of Agriculture, PJTSAU, Hyderabad, from *Kharif* 2014 to summer 2019-20 to study the impact of tillage and weed management practices adopted in rice-maize- *Sesbania* system under conservation agriculture on soil properties and soil quality. Climate of the experimental site was semi-arid. The experimental field was sandy clay loam in texture with moderately alkaline pH, low available N, medium available P and high available K. The experiment was laid out in a split-plot design with three replications. Treatments comprised of: five tillage practices, *viz.* conventional tillage-transplanted rice (CT) – CT, CT-TR – Zero tillage (ZT), CT (direct-seeded rice, DSR) – CT, ZT (DSR) – ZT(DSR) and ZT + crop residue retention (R) – ZT+R. Weed management practices tested included: bensulfuron methyl (0.6%) + pretilachlor(6%) at 0.66 kg/ha at 3-5 days after transplanting (DAT) followed by (*fb*) bispyribac sodium 25g/ha as post-emergence application (PoE) 20-25 DAS (2-3 weed leaf stage) in transplanted rice and pendimethalin 1000 g/ha PE *fb* bispyribac sodium 25 g/ha PoE at 20-25 DAS (2-3 weed leaf stage) *fb* 2,4-D sodium salt 1000 g/ha PoE at 60 DAS (in direct-seeded rice), integrated weed management (IWM) (bispyribac sodium 25 g/ha as early PoE at 15 DAT (2-3 weed leaf stage) *fb* hand weeding (HW) at 40 DAT/DAS) and unweeded control. Adopting ZT in rice and maize crops has improved soil aggregation, hydraulic conductivity, bulk density, and penetration resistance. Better aggregation and improved soil physical properties were observed with the retention of crop residues and the adoption of zero-tillage. Total organic carbon and organic carbon fractions (very-labile, labile, less-labile and non-labile) were significantly higher in ZT treatments when compared to CT treatments. Retention of crop residues in ZT treatments enhanced soil enzyme activities (dehydrogenase, urease, acid/alkaline phosphatase and catalase) over conventional tillage. Maximum bacteria, fungi and *Azospirillum* population were observed under ZT+R-ZT+R followed by ZT-ZT and lowest under CT(DSR)-CT. CT-CT recorded higher actinomycetes, phosphate solubilizing bacteria and *Azotobacter* population followed by CT-ZT. The weed management practices did not significantly alter the soils' physical and chemical properties. However, herbicide application caused a transient reduction in soil microbial counts and enzyme activities. Soil quality index (SQI), computed by principal component analysis, was highest with unweeded control in ZT+R-ZT+R (60.0) followed by IWM in ZT+R-ZT+R (57.8). The lowest SQI was observed under IWM under CT-CT (35.6) among all treatment combinations. Continuous intensive tillage caused degradation of soil health but the productivity was high whereas ZT improved the soil health but the productivity was poor. So, CT in one season followed by ZT in another season along with IWM practices have increased the soil health and productivity.

Harnessing potentials of weed-competitive rice cultivars under direct-seeded conditions

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Direct-seeded rice (DSR) has been proving to be climate-resilient, resource-efficient, and cost-effective alternative to puddled transplanted rice (PTR). Even though direct seeding has many advantages, many factors including early season flooding, poor germination under anaerobic conditions, irregular stand establishment, severe weed problems, soil sickness (micronutrient deficiencies), yield decline, and others have been linked to concerns about the medium- to long-term sustainability of DSR-based systems. One of the major obstacles to achieve full genetic potentials of rice cultivars (inbreds and hybrids) in DSR systems is the weeds. In order to make the DSR precise and more promising, it is necessary to thoroughly screen high-yielding weed-competitive rice cultivars and design their best bet agronomy while taking into account associated trade-offs (expensive seed, high output prices, etc.). The effectiveness of direct seeding techniques that require less water and labor, and favor mechanization depends on the identification, development, and/or deployment of suitable rice cultivars with robust crop establishment. Due to a smothering effect and the advantage that the crop has over the weeds, rice cultivars with early seedling emergence and vigor, rapid canopy cover, tall stature, prolific tillering ability, drooping leaves, efficient root systems, etc. are more competitive and weed-suppressive during the vegetative growth phases. Efforts have been taken up by the International Rice Research Institute (IRRI) in collaboration with different partners and stakeholders under the direct-seeded rice consortium (DSRC) to identify region-specific suitable cultivars for dry- and wet-DSR conditions across different landscapes in India. In such a recent study under wet-DSR systems at Rice Research Station, Chinsurah (Hooghly), West Bengal, the hybrids exhibit 28-49 and 17-62% higher yields than the inbreds under weed-free and partially weedy conditions during wet (*Kharif*) and dry (*boro*) season, respectively. These results suggest that improved rice cultivars of short- to medium-duration groups perform better than the long-duration cultivars under direct sowing, while hybrids are more weed-competitive and highly productive than the inbreds. In DSR systems, crop-weed competition can further be influenced by adjusting/optimizing seed rate, seeding depth and crop geometry, including row spacing and planting pattern, which can help crop plants to better compete with the weeds. Crop competitiveness is increased under narrow row spacing through faster canopy cover, better light interception, higher leaf area index, and less light penetration for developing weeds. Although the adjustment or optimization in seeding parameters and planting patterns alone is insufficient to completely suppress weeds, it can help reduce the need for herbicides and the associated environmental trade-offs. The potential benefits of using early flooding to eliminate initial weeds are limited in DSR. But it can be harnessed through introgression of QTLs for anaerobic germination and tolerance to early submergence. Rice morphological characteristics including root traits for enhanced nutrient uptake are associated with weed competitiveness. Hence, rice cultivars suitable for direct seeding should have the right combination of traits, depending on the growing conditions, cropping seasons, and crop establishment methods. These traits include anaerobic germination tolerance, seed longevity (tolerance to seed ageing), early uniform emergence, early seedling vigor and establishment, weed competitiveness, herbicide tolerance, multiple stress tolerance, lodging resistance, modified panicle architecture, efficient root system architecture, shorter crop duration (early maturity), higher input use efficiency, nematode resistance, good environmental adaptation, and higher yield potentials. These potential cultivars offer one of the safe and low-cost technologies for weed management under direct-seeded conditions.

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Weed competitive ability and crop productivity of rice cultivars as influenced by weed management practices under transplanted condition

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Weeds are one of major constraints in transplanted rice in drought-prone environment. Weeds compete with rice for moisture, nutrients, light, and space, and therefore result in yield loss ranging from 20-60% depending on nature and density of weed species, and management practices. Weeds are so complex and diverse in rice fields that no single herbicide molecule can control them effectively. Manual weeding is most common method to suppress weeds in rice but scarcity of labour for timely weeding and high labour costing are major limitations. Although herbicidal weed management offers better weed control but lead to environmental hazards. So, use of weed competitive cultivars as component of integrated weed management (IWM) would be economical. This study was carried out at ICAR-RCER, Patna, Bihar during 2018-19. Total rainfall received during the was 715.7 and 911.5 mm in 2018 and 2019, respectively. Soil was clay loam (42% sand, 35% silt and 23% clay), low in SOC (0.46%), and N (212 kg/ha), and medium in available phosphorus (26 kg P/ha) and potassium (215 kg K/ha). Experiment was laid out in a split-plot with three replications. Treatments consisted of six high yielding rice cultivars including 3 hybrids [Arize 6129 (short duration:115-120 days), Arize 6444 (medium duration:130-135), Arize Dhani (long duration:150-155)] and three varieties [Swarna Shreya (short duration:115-120 days), Rajendra Sweta (medium duration:130-135), MTU 7029 (long duration:145-150)], and three weed pressure maintenance treatments includes low weed pressure maintained with pre-emergence application (PE) of pretilachlor 0.60 kg/ha at 2 days after transplanting (DAT) followed by (*fb*) post-emergence application (PoE) of bispyribac-sodium 30 g/ha at 20 DAT *fb* hand weeding at 35 DAT; medium weed pressure; maintained with pretilachlor 0.60 kg/ha at 2 DAT *fb* bispyribac-sodium 30 g/ha PoE at 20 DAT, high weed pressure maintained as weed check. Pretilachlor 0.60 kg/ha PE was sprayed on 3rdday of transplanting with knap-sack sprayer fitted with flat-fan nozzle using 500 litres/ha spray volume. Bispyribac-sodium 30 g/ha was applied at 4-6 leaf stage (20 DAT). Major weeds recorded in transplanted rice were: *Brachariaria ramosa, Trianthema portulacastrum Cyperus rotundus, Echinochloa colona, Caesulia axillaris* and *Physalis minima*. Significantly lowest weed density and biomass were recorded in low weed pressure management. Rice hybrids, *viz., Arize 6444* and *Arize Dhani*, and rice variety *Swarna Shreya* resulted in significantly lower weed biomass. Hybrids have better weed competitive ability than varieties. Long-duration and lower height rice variety MTU 1010 was susceptible to weed competition. Early duration hybrid *Arize 6129* with low weed pressure recorded maximum rice grain yield (6.57 t/ha). Thus, growing of high yielding rice hybrids *Arize 6129, Arize 6444* or *Arize Dhani* and cultivar *Swarna Shreya* with adequate weed management (pretilachlor at 0.60 kg/ha PE fb bispyribac-sodium 30 g/ha PoE at 20 DAT *fb* one manual weeding at 25 DAT) is a better option to manage the weed and improve productivity of transplanted rice.

Tillage, residue and herbicides effects on weed and nematode dynamics, herbicide residue and productivity in a long-term CA-based direct-seeded rice

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Puddled transplanted rice (PTR)- conventional till wheat (CTW) system contributes immensely to the food security of India and South-East Asia, but, recently, its sustainability is threatened due to lots ofproblems that have cropped up, mostly related to PTR, being labour-, water-, time-, energy- and carbon-inefficient and cost-intensive. Direct-seeded rice (DSR) is a resource-efficient alternative to PTR, but weeds and nematodes pose severe challenges to its success. Conservation Agriculture (CA)-based DSR may provide an edge against weeds, which can be further scaled up by adopting better weed control practice. Therefore, this study, combining six CA/CT (conventional tillage) practices and four weed management/ herbicides treatments was conducted in a split plot design with three replications under an eight-year-old CA-based rice-wheat system to find out the impacts of these practices on weeds and nematodes, yield, economics, and herbicide residue in DSR. The CA-based DSRs encountered higher infestation of weeds and plant parasitic nematodes (PPN), such as *Meloidogyne graminicola* Golden and Birchfield (root knot nematode, RKN), *Tylenchorhynchus brevilineatus* Williams, *Pratylenchus thornei* Sher & Allenthan PTR. The zero-tillage (ZT) system in two crops in sequence without residue [~zero-tillage DSR (ZTDSR) *fb* zero-tillage wheat; (ZTW)] had highest density and dry weight of grassy weeds, whereas the ZT system in three sequential crops without residue [~ZTDSR-ZTW- ZT mungbean (ZTMB)] had highest density and dry weight of broad-leaved and sedges. But, the ZT system with three crops residue [~ZTDSR + mungbean residue (MBR) *fb* ZTW + rice residue (RR) *f b*ZTMB + wheat residue (WR)] brought about significant reduction in weed interference and was comparable with PTR-CTW. Among 14 weeds present in DSR, four grassy weeds and one broad-leaved weed were infested with RKN. RKN was found for the first time in weed *Dinebra retroflexa* (Vahl) Panz. The RKN galls were highest in the ZTDSR+WR+BM (brown manuring)- ZTW+RR treatment, but the ZTDSR+MB-ZTW+RR-ZTMB+WR system could reduce RKN galls by 72% in *Echinochloa colona*, 58% in *Echinochloa crusgalli*(both weeds), and 56% in rice crop. It also reduced PPNs like *M. graminicola* by 39%, *T. brevilineatus* by 32%, and *P. thornei* by 26% in soil, and gave 6.3-22.7% higher yield than other DSRs. The application of pyrazosulfuron-ethyl *fb* cyhalofop-butyl + bispyribac-sodium could reduce weeds and PPNs significantly and gave higher rice yield by 17.6%, 19.6%, and 7.7% compared to unweeded control, pyrazosulfuron-ethyl *fb* cyhalofop-butyl+bispyribac-sodium (tank-mix), and pendimethalin *fb* bispyribac sodium, respectively. The residues of pyrazosulfuron-ethyl, cyhalofop-butyl, bispyribac-sodium in soil, rice grains and straw were below the detectable levels and safe to humans and animals, and the crops grown in sequence. Thus, the CA-based ZTDSR with three crops in sequence and residue supplemention along withthe sequential herbicides application can lead to a better weed and nematode management, and comparable rice yield and net returns with DSR and could be an alternative to PTR-CTW in the Indo-Gangetic Plains of India and in similar agro-ecologies of the tropics/sub-tropics.

Response of black rice to date of transplanting and integrated weed management under SRI

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A field experiment was conducted to study the response of black rice (*Oryza sativa* L.) to date of transplanting and integrated weed management under SRI, at the experimental farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema campus during the *Kharif* season of 2019 and 2020. The experiment was laid out in split-plot design with three dates of transplanting *viz.* D_1-15th June, D_2- 30th June and D_3- 15th July in the main plots and five integrated weed management treatments *viz.* W_1- weedy check, W_2- cono weeding twice at 20 and 40 DAT, W_3-pretilachlor 0.75 kg/ha at 3 days after transplanting (DAT) followed by (*fb*) handweeding at 40 DAT, W_4-pretilachlor 0.75 kg/ha at 3 DAT *fb* conoweeder at 40 DAT and W_5-pretilachlor 0.75 kg/ha at 3 DAT *fb* bispyribac-Na 25 g/ha at 20 DAT in the sub-plots. The dominant weed flora observed in the experimental field were *Fimbristylis miliacea, Cyperus esculentus, Cyperus iria, Cyperus kyllingia, Ludwigia linifolia, Mimosa pudica, Mimosa diplotricha, Scorporia dulscis* and *Paspalum distichum*. Minimum weed density, weed dry biomass and higher weed control efficiency were recorded with transplanting at 15th June. It also recorded significantly lower NPK depletion by weeds and higher NPK uptake by crops. Among the integrated weed management treatments, pretilachlor 0.75 kg/ ha at 3 DAT *fb* handweeding at 40 DAT recorded higher growth, yield attributes, yield and protein content of black rice followed by pretilachlor 0.75 kg/ ha at 3 DAT *fb* bispyribac-Na 25 g/ha at 20 DAT. It also recorded significantly lowest weed density, weed biomass, NPK depletion by weed and higher weed control efficiency, NPK content and uptake by crops. The pooled results revealed that transplanting at15th June recorded significantly highest growth and yield attributes and yield of black rice *viz.* plant height, number of green leaves/plant, number of tillers/hill, dry matter accumulation, crop growth rate, number of panicles/ m^2, length of panicle, weight of panicle, number of grains/panicle, grain yield, straw yield and harvest index (32.22%). Economic analysis revealed that the maximum gross return and net return were obtained with the combination of date of transplanting at 15th June and pretilachlor 0.75 kg/ha at 3 DAT *fb* handweeding at 40 DAT. However, the highest BC ratio was obtained with date of transplanting at15th June combined with pretilachlor 0.75 kg/ha at 3 DAT *fb* bispyribac-Na 25 g/ha at 20 DAT indicating that adoption of this treatment for weed management could result in profitable production of black rice.

Bio-efficacy of tank mixed herbicides with urea in wet-seeded rice

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Herbicide use has become a necessity in agriculture, especially in rice production, where weeds constitute the most detrimental of the biotic production restrictions. The widespread idea is that using herbicides with fertilizers like urea will increase their effectiveness against weeds. Herbicides had a synergistic and antagonistic effect on major rice weeds when mixed with urea. From October to January 2019-20 and 2020-21, field experiment was conducted at *Alappad padasekharam* in the Kole lands of Thrissur. The soil in the experimental field was clayey in texture, high in organic carbon (1.1-1.3%), low in available nitrogen (180-188 kg/ha), medium in phosphorus (20-21.5 kg/ha), and medium in potash (152-159 kg/ha), with a pH of 4.5-4.7. Urea, factomphos, and muriate of potash were used to supply nitrogen, phosphorus, and potassium at 90:35:45 kg/ha each. There were 12 treatments. Six herbicides were applied with and without urea (1%) mixing, including cyhalofop butyl (0.08 kg/ha), (cyhalofop butyl + penoxsulam) (0.15 kg/ha), bispyribac-sodium (0.025 kg/ha), fenoxaprop-p-ethyl (0.06 kg/ha), carfentrazone-ethyl (0.02 kg/ha), and chlorimuron-ethyl + metsulfuron methyl (0.004 kg/ha). Hand weeded and unweeded controls were also included, for comparison. The a randomized block design with three replications was used. Rice was established as wet-seeded rice using a seed rate of 100 kg/ha. On tank mixing of herbicides with urea, bispyribac-sodium, cyhalofop butyl + penoxsulam and urea interacted synergistically, resulting in total lowest weed density at 15 days after application (DAA) (23 and 23, respectively) and 30 DAA (31 and 31, respectively) and total lowest weed biomass at 15 DAA (28.07 and 30.26 kg/ha, respectively) and 30 DAA (76.47 and 79.43 kg/ha, respectively). The high weed control efficiency at 15 and 30 DAA was with (cyhalofopbutyl + penoxsulam) + urea (83.75 and 78.91% respectively), and bispyribac-sodium + urea (82.48 and 78.10% respectively). The weed index was lowest (1.89%) with bispyribac-sodium + urea, followed by (cyhalofop-butyl + penoxsulam) + urea (3.64%). Highest grain yield (5.03 t/ha) and profitability (₹ 93,509/ha) was recorded with bispyribac-sodium + urea. The (cyhalofop-butyl + penoxsulam) with urea recorded next highest grain yield (4.94 t/ha) and net returns (₹87,463/ha).

Evaluation of suitable weed management practices for semi-dry rice

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Rice (*Oryza sativa* L.) occupies the first place among the cultivated cereals and is grown under different agro-climatic conditions. In India, the total production and productivity of rice during 2020-21 is 118.4 million tonnes and 2.7 t/ha, respectively. Weeds pose a serious threat in direct-seeded rice compared to transplanting due to alternate wetting and drying. Thus, the success of direct-seeded rice depends on effective weed management. Though manual weeding is the best but due to higher labour requirement, there is a need to use herbicide but the use of herbicides alone does not provide effective and sustainable weed control. Therefore, there is a need to integrate herbicide with alternate weed management approaches or pre-emergence herbicide followed by a post-emergence herbicide for effective weed management in direct- seeded rice. The study was conducted to evaluate suitable weed management practices for semi-dry rice. Field research was conducted at Agricultural Research Station, Paramakudi, during September 2017 and September 2018. The experiment was conducted using a split plot design with eighteen treatment combinations and replicated thrice. The main plot treatments were *viz,* irrigation when water level drops to at 10 cm below soil surface, irrigation when water level drops to at 15 cm below soil surface, irrigation when water level drops to at 20 cm below soil surface, and sub plot treatments were pre-emergence application (PE) of pendimethalin at 1.0 kg/ha at 3 days after soaking rain (DAS) followed by (*fb*) one hand weeding at 30 DAS, early post-emergence bispyribac-sodium at 25 g/ha at 15 DAS *fb* one hand weeding at 30 DAS, pre-emergence pendimethalin at 1.0 kg/ha at 3 DAS *fb* Star weeder at 30 DAS, early post-emergence application (EPoE) of bispyribac-sodium at 25 g/ha at 15 DAS *fb* star weeder at 30 DAS, pendimethalin at 1.0 kg/ha PE at 3 DAS *fb* bispyribac-sodium EPoE at 25 g/ha at 15 DAS, and hand weeding twice at 20 and 40 DAS. The pendimethalin at 1.0 kg/ha PE at 3 DAS *fb* one hand weeding at 30 DAS had significantly influenced the different weed parameters. However, at 30 and 45 DAS, pendimethalin 1.0 kg/ha PE on 3 DAS *fb* bispyribac-sodium at 25 g/ha EPoE on 15 DAS gave best performance on weed control with lower weed index of 8.78% and 8.66% during both the cropping period and higher weed control efficiency (93.90% and 97.37%) at 45 DAS during September 2017 and September 2018. The plant height (92.1cm and 90.1cm) and dry matter production (9.84 t/ha and 9.38 t/ha) at harvest stage were recorded with pendimethalin PE at 1.0 kg/ha on 3 DAS *fb* bispyribac-sodium EPoE at 25 g/ha on 15 DAS during September 2017 and September 2018. It could be concluded that pendimethalin at 1.0 kg/ha PE on 3 DAS *fb* bispyribac-sodium EPoE at 25 g/ha on 15 DAS was effective in weed control and it was suitable for semi-dry rice.

Influence of integrated nutrient and weed management on yield and weed dynamics of semi dry rice

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A field experiment was conducted during *Kharif* seasons of 2016 and 2017 at College Farm, Agricultural College, Aswaraopet, Bhadradri Kothagudem District, Telangana State to evaluate and identify suitable nutrient and weed management practices for semi dry rice. The experiment was conducted in a split plot design with three replications. Three nutrient management treatments assigned to main plots include: M_1: 100% recommended dose of fertilizer (RDF), M_2: 75% RDF + 25% nitrogen (N) using vermicompost and M_3: 75% RDF + 25% N using FYM. The four sub plots of weed management include: S_1: control, S_2: pre-emergence application (PE) of bispyribac-sodium 25 g/ha followed by (*fb*) hand weeding 20 and 40 days after sowing (DAS), S_3: early post-emergence application (EPoE) of bispyribac-sodium 25 g/ha *fb* fenoxaprop-p-ethyl 62.5 g/ha + 2,4 – D 0.5 kg /ha post-emergence application (PoE) at 35 - 40 DAS and S_4: bispyribac-sodium 25 g/ha PE *fb* pyrazosulfuron-ethyl25 g/ha + 2, 4-D0.5 kg/ha PoE *fb* hand weeding (HW) at 50 DAS. The soil of experimental field was sandy clay loam in texture with low nitrogen and organic carbon in the soil. The predominant weed flora occurred in the experimental field during both the years include:*Alternanthera sessilis, Trianthema portulacastrum, Euphorbia geniculata, Eclipta alba*, *Commelina benghalensis*, *Ludwigia perennis*, *Spilanthes acmella*, *Sphaeranthus indicus*, *Malvastratum coramandelianum*, *Oldenlandia corymbosa* and *Mollugo nudicaulis* were found among broad-leaved weeds: *Cynodon dactylon, Dactyloctenium aegyptium, Digitaria sanguinalis, Echinochloa colona*, *Eleusine indica*, *Brachiara mutica* and *Panicum repens* among grasses and *Cyperus rotundus* and *Cyperus iria* were the sedges. Among nutrient management treatments, density of broad-leaved weeds, grasses and sedges; total weed density and biomass was minimum and rice grain yield was maximum with 75% RDF + 25% N through vermicompost. While 100% RDF registered maximum density of broad-leaved weeds, grasses, sedges, total weed density, weed biomass and minimum rice grain yield. Regarding weed management treatments, bispyribac-sodium25 g/ha PE *fb* pyrazosulfuron-ethyl25 g/ha + 2, 4-D 0.5 kg/ha PoE *fb* HW at 50 DAS significantly lowered the density of broad-leaved weeds, grasses, sedges, total weed density, weed biomass and recorded higher weed control efficiency and rice yield.

Management of complex weed flora of dry direct-seeded rice with sequential use of herbicides under different tillage practices in eastern India

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A field study was conducted in a fixed plot for two consecutive years during 2019-20 to 2020-21 at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal to evaluate the effect of tillage and herbicides on weed population dynamics, weed growth and productivity of rice (*Oryza sativa* L.) under rice-yellow sarson (*Brassica campestris* L var. *yellow sarson*) crop sequence. The experiment was laid out in split-plot design with three replications. Two tillage practices comprising of zero tillage (ZT) both in rice and yellow sarson and conventional tillage (CT) both in rice and yellow sarson were allocated to the main plot and six herbicide combinations [pre-emergence (PE) oxadiargyl followed by (*fb*) post-emergence (PoE) bispyribac-sodium; PoE penoxsulam + cyhalofop-butyl (ready-mix); oxadiargyl *fb* penoxsulam + cyhalofop-butyl; PoE fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix); oxadiargyl *fb* fenoxaprop-p-ethyl + ethoxysulfuron; PE pendimethalin *fb* bispyribac-sodium] and two control (weed free check and unweeded) were assigned to the sub-plot in rice. *Digitaria sanguinalis*, *Cyperus iria* (L.), *Fimbristylis miliacea* (L.) Vahl and *Ludwigia parviflora* (Jacq.) Raven were the most dominant weed species. In the second year, after one cycle of rice-yellow sarson cropping, CT exhibited 17.4% lower total weed density and 25.5% higher total weed biomass as compared to ZT. Penoxsulam + cyhalofop-butyl was found less effective against *D. sanguinalis* and had no effect on *L. parviflora* in rice. Similarly, fenoxaprop-p-ethyl + ethoxysulfuron poorly controlled *C. iria, L. parviflora, S. calva* and *Hedyotis corymbosa* (L.). During the second year, *Paspalum notatum* Flüggé appeared in plots treated with oxadiargyl *fb* bispyribac-sodium and pendimethalin *fb* bispyribac-sodium under CT. *Hedyotis corymbosa* (L.) appeared in the fenoxaprop-p-ethyl + ethoxysulfuron-treated plot under ZT. While the sequential application of oxadiargyl *fb* fenoxaprop-p-ethyl + ethoxysulfuron or penoxsulam + cyhalofop-butyl was able to reduce 92.9-98.7% total weed density and 96.9-99.9% biomass in rice. The grain yield of rice was statistically equal in both the tillage practices. Thus, zero tillage with sequential application of pre-emergence oxadiargyl at 90 g/ha *fb* fenoxaprop-p-ethyl + ethoxysulfuron (90 + 15 g/ha) and oxadiargyl at 90 g/ha *fb* penoxsulam + cyhalofop-butyl (180 g/ha) in rice may be recommended for effective management of complex weed flora and higher productivity in dry direct-seeded rice in lateritic soils of West Bengal.

Studies on the molecular basis of imazethapyr resistance in *Commelina* spp. and *Echinochloa colona*

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Herbicide resistance is the naturally occurring, inheritable ability of some weed biotypes within a given weed population to survive herbicide treatment that should, otherwise, effectively control the weed population. Weeds acquiring resistance to herbicides is a normal and predictable outcome of natural selection. In that context, rare mutations confer herbicide resistance exist in wild/weed populations before any herbicide introduction. These mutations increase over the period after each herbicide application until they become predominant when the weed population is called herbicide-resistant. To understand the molecular basis of imazethapyr resistance in *Echinochloa colona* and *Commelina communis*, previously surveyed biotypes under the project entitled "Evaluation of selection pressure for *Echinochloa colona* and *Commelina communis* in soybean against imazethapyr" from 20 soybean growing districts of Madhya Pradesh, *viz*. Indore, Ujjain, Dhar, Ratlam, Mandsaur, Agar, Rajgarh, Shajapur, Bhopal, Damoh, Sagar, Tikamgarh, Chhattarpur, Ashok Nagar, Guna, Dewas, Harda, Sehore, Hoshangabad, and Raisen were used. Seeds of *Echinochloa colona* and *Commelina communis* were sown in plastic pots of 20 cm diameter and 22 cm height. The 4-5 leaf stage plants were treated with herbicide imazethapyr at 100, 200 and 400 g/ha. After herbicide application, some biotypes of *Commelina benghalensis*, *Commelina communis*) and *Echinochloa colona* showed resistance to imazethapyr up to 4X dose (400 g/ha). Genomic DNA was isolated from the freshly collected leaves of three imazethapyr resistant biotypes each of *Echinochloa colona* (8, 66, 77), *Commelina communis (*6, 24 and 32) and one susceptible biotype each of *Echinochloa colona* (DWR), *Commelina communis* (40), using the modified CTAB method. Overlapping pairs of primers specific to the Acetolactate synthase (*ALS*) gene of both *Echinochloa colona* and *Commelina communis* have been synthesized. To understand the molecular basis of imazethapyr resistance at the nucleotide level, *ALS* gene was amplified from both resistant and susceptible biotypes of *Echinochloa colona* and *Commelina communis*. Further, the ALS enzyme bioassay from the imazethapyr resistant and susceptible biotypes *of Echinochloa colona* and *Commelina* spp. was carried out. ALS activity values were standardized by the concentration of bovine serum albumin (BSA), quantified by the Bradford method, and expressed by the amount of acetoin produced per minute of incubation per milligram of protein (enzyme) (ìmol'"min-1'"mg-1 protein), determined by the standard curve of acetoin. The ALS enzyme activity was not affected by applying different doses of imazethapyr in *Commelina* spp. and *Echinochloa colona*-resistant and susceptible biotypes. Efforts are also being made to perform comparative RNA-Seq transcriptome analysis of *Commelina* spp. and *Echinochloa colona* with differential tolerance to imazethapyr herbicide.

Management of resistant *Phalaris minor* in wheat in north-western Indo-Gangetic Plains of India

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Wheat is the second most important crop after rice in India. Potential productivity of wheat is being constrained by development of herbicide resistant weed species. The indiscriminate and continuous use of herbicides led to development of resistance against different recommended herbicides. Further, adoption of high yielding dwarf verities provided conducive environment to weeds. In north-western Indo-Gangetic plains of India, little seed canary grass (*Phalaris minor*) is the most troublesome weed of rice-wheat cropping system causing 5 to 50% yield reduction and some times more than 80% depending on the severity of infestation and level of resistance. Thus, a field experiment was conducted with fifteen treatments including farmers' practice, weedy check and weed free and each replicated thrice in randomized complete block design at the Agronomy Research Farm, CCS Haryana Agricultural University, Hisar, Haryana, India During *Rabi* seasons of 2020-21 and 2021-22. The experimental field was infested by *Phalaris minor* as a grassy weed, while the *Chenopodium album, Coronopus didymus, Medicago denticulata* and *Rumex dentatus* among the broad-leaved weeds. Among different herbicides combinations applied, aclonifen + diflufenican [tank-mix (TM)] followed by (*fb*) mesosulfuron+ iodosulfuron [ready-mix (RM)] (1000 + 200 *fb* 14.4) provided conditions similar to weed free by controlling both grassy as well as broad-leaved weeds during both the years of study. Pyroxasulfone + pendimethalin (TM) *fb* mesosulfuron + iodosulfuron (RM) also resulted in higher WCE (> 90%) for both grassy and broad-leaved weeds. Metribuzin (350 g/ha) mixed with urea after first irrigation resulted in significantly lower weed biomass by grassy as well as broad-leaved weeds compared to weedy check without any crop phyto-toxicity. While, higher doses of metribuzin at 525 g/ha and 700 g/ha resulted in more phyto-toxicity of about 5 and 20.0%, respectively at 20 days after treatment (DAT), which was recovered later for its lower dose (525 g/ha). Lower grain yield (4.31 t/ha) was recorded with metribuzin 700 g/ha t mixed with urea after first irrigation as compared to other treatments. Aclonifen + diflufenican (TM)) *fb* mesosulfuron+ iodosulfuron (RM) (1000 + 200 *fb*14.4) and pyroxasulfone + pendimethalin (TM) (127.5 + 1500 g/ha, PRE) *fb* mesosulfuron + iodosulfuron (RM)(14.4 g/ha, PoE) caused 24.0% and 22.3% higher yield as compared to weedy check. Weed free treatment resulted in significantly higher grain yield (5.38 t/ha) than metribuzin 350 g/ha, 525 g/ha and 700 g/ha and weedy check treatments. So, sequential application of pre-emergence herbicides followed by post-emergence herbicides is effective to control resistant *Phalaris minor* in wheat

Impact of various depths of rice transplanting and *Salvinia molesta* compost on rice

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Field experimentation was carried out at Experimental farm, Department of Agronomy, Annamalai University, Annamalainagar, Tamil Nadu during *Rabi* season to study the performance of various depths of rice transplanting and *Salvinia molesta* compost application on the growth and yield of rice crop. The field trial was tested in split plot design and replicated thrice. Four planting depths treatments *viz*. M_1 :conventional planting at 5 cm depth, M_2 :planting at 1 cm depth under SRI, M_3: planting at 2 cm depth under SRI, M_4: planting at 3 cm depth under SRI, were assigned to main plots. The sub plot treatments were: 100% N as recommended chemical fertilizer (RDF) (150:50:50 kg N, P, K/ha), 75% N as chemical fertilizer +25% N as *Salvinia molesta* compost, 50% N as chemical fertilizer + 50% N as *Salvinia molesta* compost. Among different depths of planting, planting at 1 cm depth under SRI recorded the highest growth parameters *viz*. plant height, LAI and DMP. The lowest values of all above parameters were registered with conventional planting. Though the number of tillers/ m^2 was highest with conventional planting, it was on par with planting with 1cm/2 cm depth under SRI. With regard to yield components planting at 1 cm depth under SRI registered significantly higher yield parameters *viz*., panicle/ m^2, filled grains/panicle. The maximum grain yield of 5.72 t/ha was recorded with planting at 1 cm depth under SRI and was found on par with planting at 2 cm depth under SRI. The minimum grain yield (3.89 t/ ha) was recorded with conventional planting at 5 cm depth. Among sub plot treatments, application of 75% N as chemical fertilizer + 25% N as *Salvinia molesta* compost recorded higher growth parameters (plant height, tillers m^{-2}, LAI and DMP) and yield attributes (panicle/m^2, filled grains/panicle). The grain yield was maximum with 75% N as chemical fertilizer +25% N as *Salvinia molesta* compost application (5.85 t/ha) and lowest grain yield of 4.13 t/ha was recorded with 50% N as chemical fertilizer +50% N as *Salvinia molesta* compost application. The maximum grain yield of 6.45 t/ha was recorded with planting of rice seedling at 1cm depth and application of 75% N as chemical fertilizer +25% N as *Salvinia molesta* compost.

Investigations on herbicide resistance in *Echinochloa colona* and their management strategies under direct-seeded rice

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Rice is one of the important diverse crops grown in different agro-ecosystems. Rice production systems are undergoing many changes and one of such changes is shift from transplanting to direct seeding. Direct-seeding of rice saves water and labour by avoiding puddling of soil, nursery management and transplanting operations. It also improves soil structure, reduces greenhouse gas emission, and facilitates timely sowing of succeeding wheat and crop diversification by early maturation of rice by 7-10 days. The major problem in the success of direct-seeded rice (DSR) in the tropical countries is that of heavy weed infestation due to successive emergence of weeds and crop at the same time. Relying on chemical weed control for weed management is imparting lot of selection pressure on the weeds for herbicide resistance. *Echinochloa colona* also known as jungle rice is a small annual grass of poaceae family. It is a mimic weed in rice which makes it difficult to control by manual methods there by increasing the dependency on chemical control which may lead to the problem of herbicide resistance. Already, a total of 26 resistant reports are available on *Echinochloa colona*. Field investigations were carried out to assess the herbicide resistance in *Echinochloa colona* at University of Agricultural Sciences, GKVK, Bengaluru during summer 2020 and 2021.Based on the analysis of weed control efficiency, phytotoxicity and mortality rate data of *Echinochloa colona*, it is found that the weed have developed moderate level of resistance to pyrazosulfuron-ethyl and very low level of resistance to bispyribac- sodium at the recommended dose of application *i.e*., at 20 g/ha. But a quite good control of the weed was observed at higher doses of herbicide application (2x dose). In another study carried out to assess the existence of cross and multiple resistance, it is found that the pyrazosulfuron resistant population of *Echinochloa colona* have not shown any cross and multiple resistance to other herbicides used in the study, *viz*. bensulfuron-methyl + pretilachlor, imazythapyr, oxadiargyl, penoxsulam + cyhalofop, quizolofop-p-ethyl, cyhalofop-p-butyl, glyphosate, metamifop, topramezone, azimsulfuron, tembotrione, paraquat dichloride and atrazine at recommended dosages. In continuation to the previous studies, another field experiment was planned to test the efficacy of the best proven herbicides for controlling herbicide resistant population of *Echinochloa colona* under direct-seeded rice ecosystem. The results indicated that application of bispyribac-sodium 40 g/ha PoE at 2-3 leaf stage or bensulfuron-methyl + pretilachlor 660 g/ha PE were found to be efficient weed management practices in reducing total weed density and biomass including *Echinochloa colona*. The treatments bispyribac-sodium and bensulfuron-methyl + pretilachlor owing to their efficacy in managing weeds, recorded higher weed control efficiency and resulted in significantly higher grain yield (4.99 and 4.87 t/ha, respectively) of DSR without any phytotoxic effects on crop.

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Decontamination of heavy metal polluted environment utilizing a wide spread invasive taxa *Prosopis juliflora* in Southern India

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Heavy metal contamination needs remediation, prioritizing feasible methods to eliminate the metals or convert them into non-toxic forms to avert the potential hazard that arises from such pollution. Resolutely certain plant species have the potential to adapt, thrive, survive metal polluted conditions and correspondingly accumulate and detoxify metals, thereby such hyper-accumulating taxa offers natural based solutions for metal contaminated soils. *Prosopis juliflora* Swartz is one of such adaptive invasive taxa tends to flourishly grow in highly polluted environments across the arid and semi-arid regions of the world. Furthermore, *P. juliflora* have the desired properties (positive) of a phyto remediator such as: i.) high growth rate, ii.) proportion of high above ground biomass, iii.) high and rapidly populating trait, iv.) tolerance to stress condition (environmental, heavy metal, saline), 5) Better adaptive stress physiology to prevailing environmental condition. In such scenario, this study attempts to understand the metal bioaccumulation and detoxification physiological potential of *P. juliflora*. Under canopy composite soil (0 – 15 cm) and *P. juliflora* plant samples (root, stem, leaves, pods) were collected from 100 sites in the environs of metal-based sources (roads, factories, landfills, electronic waste dumps, and sewages, spreaded across 5500 km2) at Tiruchirappalli and Pudukkottai regions of southern part of India.Samples were subjected to heavy metal *viz*. Cu, Fe, Cr, Cd, Ni, Pb, Zn, Mn estimation, using Atomic Absorption Spectroscopy (thermo fisher iCE 3000 series). The available heavy metals content was much higher in the plant parts of *P. juliflora* (root, stem, leaf, pod) when compared to the levels in under canopy soil ($p < 0.05$* -Kruskal Wallis test). Accumulation of heavy metals in the plant parts - root and leaf was found to be high and low in stem and pods a contrast significance was observed $p < 0.01$*** (Kruskal Wallis test). Bio Accumulation Index was found to be: root, leaves, stem, pods - 9.1 > 7.5 > 6.7 > 4.0 respectively. Translocation index of metals between the plant parts decreased with the upward sap flow (root to stem: 0.76, stem to leaf: 0.58, leaf to pod: 0.33). Stress physiological metabolites like ascorbic acid, proline, and peroxidases were also quantified in plant parts. Detoxifying stress physiological metabolite proline was high in the aerial parts of the plants (leaf, pod) and a negative regression was observed (R2 –0.7702, $p<0.01$***) between proline and heavy metals, indicates significant metal detoxifying physiological potential of *Prosopis juliflora*. Thus, in a long-run, under future elevated heavy metal pollution levels an abundant naturally occurring weed *P. juliflora* can be utilized feasibly and cost-effectively in decontaminating the soil environment from heavy metal contaminations.

Ecology of weeds in rice fields: A pre-requisite for weed management

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Agricultural achievement in India during its 75 years of independence have changed country's image from food importer to potential exporter. India's population is growing at the rate of 1.9% annually and may reach up to 1.4 billion by the year 2025.The challenge to sustain food security is to develop production technologies for rainfed areas. Rainfed agricultural production plays an important role in meeting the demand of food in the future. Increasing population urbanization and industrialization have been exerting stress on croplands. To meet the demands of increased population, it is necessary that the productivity of croplands should be very high. Because of limited arable land, agriculture management has assumed new dimensions in the form of technology to cope up with situation. To keep pace with the present rate of population growth and consumption patterns, the food requirements must reach 246 million tons in near future. Production of 'green revolution' crops (wheat and rice) has declined at the rate of 2.46% since 1991. To compensate the decline in productivity, there is a need to reduce crop loss from pests, diseases and weeds. Moreover, to sustain food security, the challenge is to develop food production technologies for rainfed areas because the rainfed agricultural production plays an important role in meeting the demand of food in future. Rice is one of this. Apart from the other factors, weeds are serious impediments to crop growth and productivity. Therefore, solution of present problem lies in reducing the gap between actual production and potential production of crop by eradicating crop weeds using low cost inputs, in general and rice, in particular. Present paper deals with some of the aspects of rice field weeds of Bilaspur in Chhattisgarh.Chhattisgarh the 26th state of India is a rice growing state. About 80% of its population lives in villages which directly or indirectly depend on rice. The type of rice culture use dare mainly 'direct seeded' and 'transplanted'. In the present study the distribution and biological characteristics of the rice weed flora of the Chhattisgarh plains especially Bilaspur has been described. Extensive field survey at regular intervals was done. Preparation of herbarium, identification and classification using standard literature available was also done. Phytosociology, Community analysis using various parameters as density, abundance and percentage frequency was also determined. IVI was used an important parameter to determine their dominance. Morphology of weed seeds using as a key for identification of weed seeds was also tried. Major findings resulted that there were 58 species of weeds including Grasses as 85-89% of total weed population and 90-96% of total dry matter. Sedges and Broad leaved weeds ranked second and third. Most common, frequent, abundant and obnoxious was *Echinochloa comple* belongs to Poaceae and Cyperaceae as the most common families. Maximum% frequency was found in September and October which was the most critical period for competition also.

Ecology and biology of nutsedge

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Nutsedge (*Cyperus* spp.) is one of the most tenacious cum noxious weed which threatening natural ecosystems and agroecosystems seriously. The spread of the weed in the short time is accomplished through rhizomes, which may extend upward, downward or horizontally. When purple nutsedge (*Cyperus rotundus* L.) is cultured in field without interference from other plants, it can produce millions of tubers. Hence, the information regarding its biology, ecology and potential management options to minimize the spread and impact of sedges is paramount importance. Therefore, an investigation was carried out at the College Farm, Navsari Agricultural University during the *Kharif* season of 2021 and survey was conducted across the campus. The experiment included phonological survey to know the diversity, distribution and infestation level of *Cyperus* spp. conducted during *Kharif* and *Rabi* seasons. A pot culture study was arranged to know the biology of *C. rotundus* including its growth, flowering and tuberization pattern. Besides, yield losses due to *Cyperus* spp., infestation in different crops was also evaluated through large plot experimentation. The soil of campus was clayey in texture with medium in available nitrogen (282 kg/ha), phosphorus (36.1 kg/ha) and rich in available potassium (318 kg/ha). The soil reaction was slightly alkaline (7.3 pH) which is favorable for adequate usual growth of weeds. The species prevailing during survey in and around college campus were identified as *Cyperus rotundus, C. eragrostis*, *C. iria* and *C. compressus.* Among these, *C. rotundus* and *C. eragrostis* are perennial and predominantly exist in arable and non-arable land, whereas *C. iria* and *C. compressus* are annual and observed in marshy land during *Kharif* season only. In general, mean composition of sedges, grasses and BLWs was 45.18, 23.92 and 30.90%, respectively, during *Kharif* season, while in *Rabi*, 41.88, 21.13 and 36.99%, respectively. Regeneration of *C. rotundus* was observed at 2-3 days after planting of nuts and experienced 91 per cent regeneration at 10 days after planting (DAP). Sharp growth in term of height (more than 60%) was noticed upto 20 DAP eventually marginal addition was noticed and attained 88 cm height at 60 DAP. Similarly, increment (10.9%) of leaves was observed upto 30 DAP and subsequently decreased with maturity due to falling of older leaves. Flowering initiated when the weed produced 8 leaves on an average and 50% flowering was observed at 30-35 DAP. Profuse tuberization was noticed range from 15 to 33 tuber/basal bud with a mean of 22.1 tubers per each planted nut at 60 DAP. Besides, emergence and growth of *C. rotundus* was observed, but flowering and further development was not observed in shade condition. Cereals were observed hardier and more competitive than oilseed and pulses crop due to poor ability to compete with *Cyperus* spp. The reduction in yield due to *Cyperus* spp. infestation varied from crop to crop with the higher losses of soybean *i.e.* 33.5%, followed by pigeon pea (28.2%), cotton (25.7%), blackgram (21.4%), greengram (21.1%), groundnut (21.1%), cowpea (20.9%), sorghum (11.3%) and least was reported with sweet corn (8.4%).

Comparative study of soil weed seed bank under different cropping systems of North-West India

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Weed infestation is the major constraint and its control is a major hurdle in conservation agriculture (CA) based systems since weed ecology and management approaches are entirely different for CA systems. Weeds pose serious threat to the companion crops through their competition for nutrients, water, sunlight and space, which causes considerable reduction in yield. The sources of these huge economic losses and weed infestations in crops is primarily due to weed seed bank (WSB) which describes the reservoir of viable weed seeds or fruits found in soil or at its surface. To deplete the weed seed bank, weed seed-set should be prevented by all means and needs to be addressed in a holistic way. The present experiment was conducted at ICAR-Indian Institute of Maize Research, Ludhiana, Punjab with an objective to study and compare soil weed seed bank under different cropping systems of Northwestern India. The experiment consisted of three cropping systems, *viz*. (a) rice-wheat-moongbean system (b) maize-wheat-moongbean system under conventional agriculture and (c) maize-wheat-greengram system under conservation agriculture. The depth wise soil sampling from all the three systems was undertaken. The lower weed seed density (no./8 kg soil) of 88.67 and 118.33 was observed in rice-wheat-greengram system (conventional agriculture) at both 0-5 cm and 5-15 cm soil depths. At 5-15 cm soil depths, maize-wheat-greengram in both the systems (conventional and conservation agriculture) recorded more number of weeds than rice- wheat- greengram system (conventional agriculture). Weed density (no./8 kg soil) was highest at 0-5 cm soil depth in conservation agriculture than 0-5 cm in conventional agriculture. Highest total and average weed density (no./8 kg soil) of 508.33, 254.16 was observed in maize-wheat-greengram system (conservation agriculture) followed by 433.33, 216.66 and 207, 103.5 in maize-wheat-greengram system (conventional agriculture) and rice- wheat- greengram system (conventional agriculture) respectively. Therefore, it can be concluded that weed seeds and weed growth is highest in conservation agriculture than in conventional agriculture and needs more focus for weed management for increasing productivity and profitability of cropping systems in North Western India.

Weed dynamics as affected by different cropping systems in the irrigated midlands of Eastern Region

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Studies on weed population dynamics are based on observing and recording changes in weed species in response of different cropping systems and their management. Studies on weed population dynamics are based on observing and recording changes in weed species in response of different cropping systems and their management. Weed communities are affected by farming practices through variations in the flow of input and energy. These changes modify the weed diversity in the system and composition of species in weed communities. This study was aimed to evaluate the density and composition of the weed population in the established cropping systems with more than ten years. The specific goals were i) to highlight weed species favored by different cropping systems ii) to ascertain the density, frequency and abundance of weeds and its composition in different cropping system. The present was conducted at ICAR Research Complex, Patna Farm during *Kharif* 2018 to *Rabi* 2021 in both the seasons. Ten major cropping systems were selected for the study, *viz*. i) rice- wheat ii) rice- maize iii) rice- mustard-moong iv) rice- lentil- moong v) ruava + turmeric vi) lemon + turmeric vii) cowpea- tomato- okra viii) okra- cauliflower- onion ix) rice-cauliflower- spinach- moong and x) jowar- chickpea- fallow. Weed samples from ten major cropping systems of the region were collected at 20 and 60 DAS and were evaluated for variables: frequency (F), density (D), abundance (A), relative frequency (RF), relative density (RD) and relative abundance (RA). It was observed that during rainy (*Kharif*) season, monocot weeds, *viz. Cyperus rotundus, Echinochloa crusgalli, Echinochloa colona, Eleusine indica, Cynodon dactylon, Leptochloa chinensis, Paspalum dilatatum, Brachiaria reptans, Dactyloctenium aegyptium etc*.were found to be dominant while dicot weeds, *viz. Solanum nigrum, Anagallis arvensis, Alternanthera sessilis, Trichodesmus indicum, Euphorbia hirta, Trianthema portulacastrum, Commelina benghalensis, Oxalis corniculata, Ludwigia adscendens, Trichodesmus indicum, Medicago denticulata etc.*were found to be dominant during winter (*Rabi*) season irrespective of cropping systems. Further, rice- cauliflower - spinach - moong and Jowar- chickpea - fallow cropping systems had shown more diverse weed population than other cropping systems studied. Weed species *Cyperus rotundus* has emerged as the most dominant weed species irrespective of the crop seasons in any of the cropping system. Therefore, a suitable weed management strategies to control these noxious weed species are of quite importance for the region which will help in boosting the economic yield of the each of the crop by diminishing the losses caused by the weeds.

Effect of irrigation methods and herbicides on weed flora dynamics in direct-seeded rice

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A field experiment was conducted to assess the effect of irrigation methods and herbicidal management on weed flora dynamics in direct- seeded rice during *Kharif* 2016 and 2017 in split-plot design with 3 replications. The irrigation methods (flood irrigation and sprinkler irrigation) were in main plots and herbicidal treatments in sub-plots. The post-emergence application (PoE) of all the herbicides was done at 25 days after sowing (DAS) with 500 L water/ha. The irrigation scheduling was done on the basis of soil moisture depletion approach. In flood irrigation method 4 cm water was applied. The experimental field was dominated by *Echinochloa* spp., *Cynodon dactylon*, *Digitaria sanguinalis* and *Setaria glauca* amongst grassy weeds; *Caesulia axilaris, Phyllanthus niruri, Physalis minima* and *Euphorbia* spp. amongst broad-leaved weeds and *Cyperus* spp. Beside, these major weeds, other weeds recorded include: *Commelina benghalensi, Cucumis spp.* and *Dactyloctenium aegyptium*. Different irrigation treatments (flood irrigation and sprinkler irrigation) had non-significant effect on weed density and biomass at 30 and 60 DAS and at harvest. Among the weed management treatments, all the weed management treatments recorded significantly lower weed density and biomass, higher grain and straw yield of rice as compared to weed check. The lowest total density of grassy and broad-leaved weeds was recorded with pre-emergence application (PE) of pendimethalin 1000 g/ha followed by (*fb*) bispyribac-sodium 25 g/ ha+ ethoxysulfuron-ethyl 18 g/ha which was statistically at par with pendimethalin 1000 g/ha PE *fb* penoxsulam + cyhalofop-butyl 135 g/ha and significantly lower than all other herbicidal treatments at 60 DAS and harvest. The lowest density of *Cyperus* spp., total weed density and weed biomass was recorded in pendimethalin 1000 g/ha PE *fb* bispyribac-sodium 25 g/ha+ ethoxysulfuron-ethyl 18 g/ha PoE which was significantly lower than all other herbicidal treatments at 60 DAS and harvest. Different irrigation treatments had non-significant effect on grain and straw yield of rice. The higher grain yield and straw were recorded with pendimethalin1000 g/ha PE *fb* bispyribac-sodium 25 g/ha + ethoxysulfuron-ethyl 18 g/ha PoE which was statistically at par with pendimethalin 1000 g/ha PE *fb* penoxsulam + cyhalofop-butyl 135 g/ha PoE and significantly higher than all other herbicidal treatments. The non-significant interaction was found between irrigation method and weed management treatments with respect to weed density and biomass, grain and straw yield of rice.

Correlation and regression analysis of *Rabi* maize - weed ecosystem

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A field experiment was conducted at AICRP - WM, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi* 2019-20 and 2020-21 in lomy sand soils to study the correlation of the grain yield of maize on certain weed and crop parameters in middle Gujarat conditions. The experiment consisted ten treatments laid out in a randomized block design with three replication.After harvest, correlation and regression analysis were studied between grain yield as the dependent variable and each of the following traits as independent variables (monocot weed density (no/m^2) at 25, 50 DAS and at harvest, dicot weed density (no/m^2) at 25, 50 DAS and at harvest, total weed density (no/m^2) at 25, 50 DAS and at harvest, monocot weed dry biomass (g/m^2) at 25, 50 DAS and at harvest, dicot weed dry biomass (g/m^2) at 25, 50 DAS and at harvest, total weed dry biomass (g/m^2) at 25, 50 DAS and at harvest, weed control efficiency at 25, 50 DAS and at harvest, straw yield, plant stand at 30 DAS and at harvest and plant height at 30 DAS, 60 DAS and at harvest). The grain yield was highly negatively correlated with density and dry biomass of weeds at 25 and 50 DAS as well as at harvest in pooled analysis, while non-significant positive correlation was observed with weed control efficiency at 25 and 50 DAS but, highly significant positive correlation was found with weed control efficiency at harvest in pooled analysis. The correlation coefficient between grain yield and periodical plant height, straw yield and plant stand at harvest were highly significant positive correlation in pooled analysis. The plant stands at 30 DAS showed non-significant positive correlation. As regards the predictions pertaining the reduction in grain yield due to monocot weed density, dicot weed density and total weeds density, it was in the order of 0.0079, 0.0104, 0.0046 t/ha at 25 DAS, 0.0148, 0.0296, 0.0101 t/ha at 50 DAS and 0.0389, 0.0503, 0.0259 t/ha at harvest for monocot weeds density, dicot density weeds and total weeds density respectively in pooled analysis. Prediction pertaining the reduction in grain yield due to monocot weed dry biomass, dicot weed dry biomass and total dry weed biomass, it was in the order of 0.0231, 0.0501, 0.0161 t/ha at 25 DAS, 0.0124, 0.0259, 0.0083 t/ha at 50 DAS and 0.0121, 0.0182 0.0076 t/ha at harvest for monocot weeds dry biomass, dicot weeds dry biomass and total weeds dry biomass respectively in pooled analysis. The prediction pertaining the increase in grain yield due to weed control efficiency at 25 DAS, 50 DAS and harvest, it was in the order of 0.0093, 0.0237, 0.0187 t/ha respectively for weed control efficiency at 25 DAS, 50 DAS and harvest in pooled analysis.

Restriction of *Cyperus rotundus* population in turf (*Cynodon dactylon*)

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Cyperus rotundus is the most noxious weed for turf grass and turfing industries. An experiment was conducted at ASPEE College of Horticulture and Forestry, NAU, Navsari to study the effectiveness of different herbicides at appropriate concentration for the management of *Cyperus rotundus* in turf (*Cynodon dactylon* var. *Selection-1)*. Healthy springs of lawn with excellent physical appearance were planted at a distance of 10 × 10 cm in 9.0 m^2 area. Meanwhile, the mature tuber of *Cyperus rotundus* having 1.0 to 1.5 cm length were artificially inoculated at distance of 30 × 30 cm in a same plot after 5 days of lawn planting. The experiment was laid out in randomized block design (RBD) with three replications. The foliar application was made to test eight treatments, *viz.* halosulfuron-methyl 75% WG 2.4 g/10 L and 3.3 g/10 L, ammonium salt of glyphosate 71% SG 75 g/10 L and 100 g/10 L, ammonium salt of glyphosate 41% SL 110 ml/10 L and 150 ml/10 L, 2,4-D ammonium salt 30 g/10 L and 40 g/10 L and they were compared with manual weeding – weed free as well as untreated – weedy check. The foliar application of halosulfuron-methyl 3.3 g/10 L at 4 to 6 leaf stage of *Cyperus rotundus* was found effective to reduce weed biomass and attain maximum weed control efficiency with low re-emergence of *Cyperus* population up to 60 days after application in lawn with appropriate growth attributes of lawn, *viz.* chlorophyll content and good aesthetic appeal in the sense of better colour, texture, compactness and smoothness. Eventually, halosulfuron-methyl 3.3 g/10 L eliminated the awful competition and combating re-emergence of *Cyperus* population through maximum damage on tubers and stem as well as vascular tissue of *Cyperus rotundus* without any phytotoxicity effect on lawns.

Germination ecology and influence of length and orientation of stolon fragments on invasiveness of *Alternanthera bettzickiana*

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Alternanthera bettzickiana (Regel)Voss., commonly known as calico plant, is a stoloniferous spreading perennial herb, which has been recently attaining the status of invasive weed in many parts of the world. It is a dicotyledonous, bushy or ascending herb which now appears as a major weed in vegetables, tuber crops, fruits and vegetables and is found throughout the plains, degraded deciduous forests and wastelands in the southern and north-eastern states of India. Germination of seeds is influenced by various environmental factors like temperature, light, soil moisture, soil salinity and acidity, existing crop residues and depth of seed burial. Several invasive species can procreate clonally via rhizomes and stolons, in addition to sexual reproduction and therefore, understanding the factors affecting the survival, regeneration and growth of the stolon fragments is of practical interest in the management of invasive weeds. Laboratory and pot experiments were conducted to study seed longevity and effect of temperature (22, 26, 30 and 34ºC), light (continuous light, continuous dark and alternate light and dark), soil moisture [100, 75 and 50% water holding capacity (WHC)] and depth of seed burial (at 0, 2, 4 and 8 cm) on seed germination of *A. bettzickiana*. As it is a stoloniferous plant, the influence of length (4 cm and 8 cm) of stolon fragments and their orientation (0º, 45º and 90º) on survival and growth of the ramets were also assessed. Higher germination of 78.3 and 76.7% occurred when seeds were exposed to a temperature of 30 and 34ºC, respectively, and under continuous light condition. Germination was completely inhibited when seeds were subjected to lower temperatures, irrespective of light conditions. Emergence of *A. bettzickiana* decreased with increase in depth of placement of seeds in the soil. Emergence from surface placed seeds was 73% at fourth week of sowing which declined with increase in depth and complete inhibition of germination was observed with seed placement beyond 5 cm. Significantly higher seedling vigour index, seedling length and biomass were recorded with higher moisture content of 100 and 75% WHC of the soil and were significantly lower at 50% WHC. Seed longevity trials showed that seeds beyond the age of nine months failed to germinate and highest germination percentage was observed for five-month-old seeds. Seeds buried at a depth of 4 cm recorded highest germination, followed by those buried at 2 cm depth, irrespective of age of seeds. Significantly lower germination per cent was recorded by seeds placed on soil surface. Length of stolon fragments had a significant effect on growth and final size of the ramets, whereas orientation of the fragments imparted no significance difference on growth parameters. At any orientations, stolon fragments of higher length (8cm) resulted in more vigorous plants with higher number of leaves, branches, nodes and biomass. Interaction effect of fragment length and orientation on their survival and final size was also proved to be non-significant. Knowledge on biology and ecology of weeds can aid in effective control of invasive and problematic weeds. Present study along with other data regarding seed bank dynamics of *A. bettzickiana* could contribute to formulate economically and ecologically sound methods for managing this weed.

Study on biology of *Echinochloa colona* in direct-seeded rice

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According to reports, *Echinochloa colona* is considered as most hazardous summer grassy weed that is found worldwide in various summer crops, including rice and maize. *E. colona* competition effects are more obvious in direct-seeded rice as compared to transplanted rice because of crop-weed interference during the early growth stages of rice. High densities of *E. colona* have been reported in 24 countries in direct-seeded rice. It has vigorous growth traits, high seed production capacity and reduces grain yield of rice worldwide by 27 to 62%. An attempt has been made to study the biology of *E. colona* in terms of the effect of burial depth on its emergence pattern during *Kharif* season under pot condition. The results revealed 88% emergence within 13 days of 8 months old seeds present on surface soil, however, 44, 42, 32, 32, 18, 16, 12, 2 and 2% emergence were rerecorded from 1, 2, 3, 4, 5, 6, 7, 8 and 9 cm soil depth at 20th day from inception of the experiment, respectively. Finally, at 33rd day 88, 46, 42, 38, 38, 20, 20, 18, 6 and 6% emergence were recorded from 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 cm depth, respectively, after that no emergence was registered from any of the soil depth. Altogether, 34% emergence was recorded beyond 20th day and majority of the seedlings' emergence was contributed from the seeds placed at greater depth of soil. *E. colona* plants initiated first inflorescence from 34th to 40th day and complete dropping of seeds from all the inflorescences was recorded within 48 to 59 days in case of the weed emerged from 0 to 7 cm soil depth. However, considerable delay in initiation of inflorescence from 51st to 55th day and complete dropping of seeds from all the inflorescences within 72 to 77 days were recorded from the *E. colona* plants emerged from 8 to 9 cm soil depth. Synchronization of inflorescences' emergence and shorter duration from initiation of first inflorescence to complete dropping of seeds ranging from 14 to 19 days were recorded from the *E. colona* plants emerged from 0 to 7 cm soil depth. However, staggered emergence of inflorescences and longer duration from initiation of first inflorescence to complete dropping of seeds ranging from 21 to 22 days were recorded from the *E. colona* plants emerged from 8 to 9 cm soil depth. Current seeds of *E. colona* have started to emerge at 38th day after complete dropping of the seeds. In weedy plots of direct-seeded rice, *E. colona* plants contributed the average number of 3981 seeds/m2 on surface soil ranging from 1806 to 5556 seeds/m2 at 60 days after sowing of rice. *E. colona* in weedy plot on an average produced highest number of seeds (6478 seeds/plant). Among the treatments evaluated in DSR, pre-emergence application of penoxsulam + pendimethalin (ready-mix) followed by post-emergence application of fenoxaprop-ethyl + ethoxysulfuron recorded an average of 2443 seeds/plant of *E. colona* with maximum reduction in seed production (~62%) as compared to the weedy check treatment.

Allelopathic effect of aqueous root leachates of *Echinochloa colona* on seed germination and seedling growth of rice

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Janjgir-champa district in Chhattisgarh state is situated between 22˚03` N latitude and 82˚47` E longitude. Red and yellow soil of Chhattisgarh are of alluvial origin. The climate is wet and humid in general interspersed with rainy months. Temperature ranges between 11°C to 43°C and average rainfall is 1200 to 1500 mm per year. The type of rice (*Oryza sativa)* culture used is mainly "direct-seeded" and "transplanted". Direct-seeded rice suffers more from weed infestations than the transplanted rice. Grasses make 85 to 89% of the total weed density and 90 to 96% of the total weed biomass. The present study was undertaken to assess the allelopathic effect of *Echinochloa colona* (L.) Link in relation to the germination and seedling growth of *Oryza sativa* (rice). Plants of *E. colona* were collected from neighbouring fields of Janjgir-Champa. Plant parts were chopped into small pieces and oven dried at 48°C for 48 hours in powder form. Seeds of rice were obtained and stored in glass stoppered bottles at room temperature. Five gram of oven dried stem, leaf and root powder and weed seeds were soaked separately in 100 ml of distilled water for a period of six days. After storage dark brown leachates were obtained which were used as standard leachates (stock solutions) and diluting it with distilled water. Different concentrations (stock solutions: water) or dilution were 1:5, 1:25, 1:50, 1:100, 1:150, 1:250, 1:350, 1:500, control and their pH value were determined by using pH meter and also percentage germination was observed. Experiments on seed germination and seedling growth were conducted in sterilized condition (0.1% solution of mercuric chloride). The criterion for germination was visual detection of radicle. Observations were taken till there was no more germination. Seedling growth was estimated by measuring plumule and radicle growth of ten seedlings. With increasing dilutions of root extract, percentage germination and seedling growth was also increasing in all the crop seeds. Only 27.77% germination was recorded in 1:5 concentration of *E. colona* root extract while at the same concentration leaf, stem and seed extracts resulted in 36.66%, 64.44% and 65.55% germination of rice seeds. However, the inhibitory effect decreased with increasing dilution of extract of all plant parts. The maximum inhibition of germination was recorded for leachates obtained from roots of *E. colona*. According to their inhibitory effect the leachates of different plant parts of this weed may be arranged as root Ã leaf Ã stem Ã seed. The percent reduction in germination of rice by root, leaf, stem and seed leachates of *E. colona* was 58.48%, 45.59%, 30.56% and 23.2%, respectively. This leads to the speculation of some allelopathic effect of weed *E. colona* to the rice crop.

Weed flora shift and wheat competitiveness under diverse nitrogen levels

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Weeds compete with wheat (*Triticum aestivum*) for nutrients, light and soil moisture, therefore, seriously limit wheat productivity. Nitrogen (N) is the most important nutrient supplied to most non-legume crops, including wheat. Nitrogenous fertilizer application is known to alter weed seed germination, emergence, and growth. Therefore, it is important to develop N management strategies that enhance the competitive ability of the wheat crop and minimize weed competition. Hence, field trials were conducted at Research farm of ICAR-IARI, New Delhi during winter season of 2020-21 and 2021-22 to understand the weed flora shift and wheat competitiveness at different N levels. Seven levels of N (0, 40, 80, 120, 160, 200, and 240 kg N/ha) were applied to wheat crop through urea in three equal splits (basal, CRI and maximum tillering). Weed counting and dry matter measurement were done during flowering stage during 2021-22. During the cropping season, the major weeds were *Avena ludoviciana, Phalaris minor*, *Chenopodium album*, *Convolvulus arvensis, Melilotus alba* and *Fumaria parviflora.* Weed density was inversely related with N fertilizer application. Two- and three-times higher weed density was observed at control plot as compared to recommended dose of fertilizer and 240 kg N/ha. Weed flora shift was also noticed in this experiment. Wild oat was completely absent in control plot and at 40 kg N/ha while, its population density increased with increased N levels. Significantly the highest wild oat count (20/m^2) was observed at 240 kg N/ha. Oppositely, more number of *Chenopodium album*-a broad-leaved weed (265/m^2), was observed in N deficient plot (control) which was five times higher than its count in 240 kg N/ha. Moreover, the highly fertilized soils favoured luxuriant growth and improved biomass of single weed plant, while total weed biomass was more at control plot followed by 40 kg N/ha and 80 kg N/ha.In nutshell, nitrogen fertilizer application increases the crop competitiveness against weeds through higher tillering, robust canopy and lesser PAR interception at ground, therefore mind-full application of N fertilizer can reduce the weed burden in wheat crop. Furthermore, nitrogen application favors monocotyledon weeds while, nitrogen deficiency aggravates the problem of broad leaf weeds in wheat crop.

Integrated weed management in *Bt* cotton

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Cotton is one of the most important commercial crops and it plays important role in the Indian economy. Being a long duration and widely spaced crop, the yield loss of seed cotton in India due to weed competition ranges between 50 to 85%. Weed management plays very crucial role because wide spacing, initial slow growth, continuous rainfall and heavy use of nutrients provide enough room for profuse growth of weeds. Weeds being naturally hardy and competitive; compete well with crop for moisture, nutrients, light and space results in poor yield of crop. In view of the variety of weed flora, feasibility and conveniences, it is inappropriate to adopt any single method of weed management, thereby emphasizing integrated approach in this regard. A field experiment was conducted at Main Cotton Research Station, Surat involving ten treatments, *viz.* weedy check, cultural practices [hand weeding (HW) at 20, 40 and 60 days after seeding (DAS) and intercultivation (IC) at 45 and 90 DAS) and different rates of herbicides [pendimethalin and fluchloralin as pre-emergence application (PE) and quizalofop-ethyl as post-emergence application (PoE)]. All the herbicides and cultural operation treatments decreased weed density significantly than weedy check. Low weed density as well as biomass was recorded with pendimethalin 1.0 kg/ha PE followed by (*fb*) HW at 30 and 60 DAS, followed by fluchloralin 0.75 and 1.0 kg/ha PE *fb* HW at 30 and 60 DAS and HW thrice at 20, 40 and 60 DAS and IC twice at 45 and 90 DAS. The highest weed control efficiency (WCE) was observed with pendimethalin 1.0 kg/ha PE *fb* HW at 30 and 60 DAS, followed by fluchloralin 0.75 or 1.0 kg/ha PE *fb* HW twice at 30 and 60 DAS and the local practices. The higher WCE with the above treatments could be attributed to lower weed dry bio-mass. Growth and yield attributes were affected remarkably due to different treatments. All herbicidal treatments as well as HW twice at 20, 40 and 60 and IC at 45 and 90 DAS resulted in more number of sympodial branches, bolls per plant and boll weight over weedy check. The highest seed cotton yield and maximum net monetary returns were recorded with pendimethalin 1.0 kg/ha PE *fb* HW twice at 30 and 60 DAS. Thus integrated weed management practice is effective, efficient and economical to control weeds in *Bt* cotton.

Chemical weed control in foxtail in Karnatka

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Foxtail a minor millet is amazing for its nutritional aspects. In recent times due to health consciousness, consumption of minor millets is gaining popularity and thus more importance has been given for improved cultivation practices. Among all the production factors, weed pose serious threat, they compete with the crop plants for essentials of growth thus adversely affect crop production. Foxtail millet during its early stage exhibit slow growth till first 3 to 4 weeks, this provides enough opportunity for weeds to invade and offer severe competition resulting in 40-50% yield reduction. Keeping a crop weed free throughout the crop season is a labour and cost intensive affair. Hand weeding is laborious, difficult to execute under frequent intermittent rains, cumbersome and time consuming. Use of herbicides is the best option to reduce the weed menace. With this background an attempt was made to screen the post-emergence herbicides for safe and efficient weed control, as no herbicides has been evaluated in foxtail millet. The field experiment was conducted during the *Kharif* season from 2020-21 to 2021-22 at AICRP-Weed Management, Bangalore to study the crop toxicity and efficacy of different post-emergence herbicides application on weed control. Two years' data indicated that among the different herbicides screened, application of bispyribac-sodium 10 EC 15 and 20 g/ha and ethoxysulfuron 15 WG 18.75 g/ha showed leaf tip scorching and delay in growth till 17 days after herbicide application (DAHA). Further no toxicity on crop were noticed after 17 DAHA.Lesser weed density and weed dry weight (51.33 no./m^2 at 30 DAS and, 38.67 no./m^2 and 12.90 g/m^2 at 60 DAS) were recorded under metsulfuron-methyl + chlorimuron-ethyl 20 WP 4 g/ha *fb* 2, 4 D sodium salt 80 WP 1000 g/ha which recorded 57.67 no./m^2 and 5.54 g/m^2 at 30 DAS and 38.33 no./m^{2}and11.58 g/m^2 at 60 DAS compared to weedy check (98.67 no./m^2 and 6.73 g/m^2) at 30 DAS and at 60 DAS (70.33 no./m^2 and 14.88 g/m^2). Use of these herbicides noted remarkable savings in weed cost ranging from ₹ 6449 to 6508/ha. Highest seed yield was recorded with post-emergence metsulfuron methyl + chlorimuron-ethyl 20 WP 4 g/ha (0.81 t/ha) and 2,4-D sodium salt 80 WP 1000 g/ha (0.86 t/ha). The savings over farmer practice varied from ₹ 7600 to7732/ha on application of these herbicides to control weeds. Among the above herbicides screened, metsulfuron-methyl + chlorimuron-ethyl 20 WP 4 g/ha (targets only BLW and sedges) and 2,4-D sodium salt 80 WP 1000 g/ha (controls broad-leaf weeds-BLW) can be effectively used as early or post-emergent herbicides for controlling weeds in foxtail millet.

Influence of herbicides and agri-horti systems on growth and yield of finger millet under semi-arid condition of Eastern Uttar Pradesh

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India's population is growing rapidly, while the size of an average farm holding is shrinking. Thus, to fulfil the nutritional requirement in semi-arid conditions of Vindhyan zone, it is essentially required to introduce finger millet as alley crop under agri-horti system. It is noteworthy that the success of introduced alley species largely depends on compatibility of component species. Further, being finger millet a rainy season crop, heavily infested with weeds, whose intensity and floristic diversity differs with the agroforestry systems, which ultimately affects the crop growth and yield. Thus, an experiment was conducted to work out the compatible agri-horti system and herbicide options for enhancing yield of finger millet. Experiment was undertaken in split plot design, main factor consists of three agri-horti systems [guava (*Psidium guajava*), bael (*Aegle marmelos*) and open-field], whereas, in sub-plots, 4-herbicidal treatments [oxyflourfen 0.1 kg/ha pre-emergence application (PE) followed by (*fb*) clodinafop 60 g/ha post-emergence application (PoE), bispyribac-Na 20 g/ha early PoE, isoproturon 0.75 kg/ha PE *fb* 1-hand weeding (HW) at 30 days after seeding (DAS), pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 0.04 kg/ha PoE were compared with -hand weeding twice at 20 and 40 DAS and weedy check. The experimental soil was low in organic carbon (0.32–0.36%), available nitrogen (165.45–175.83 kg/ha), whereas, available phosphorus (12.41–16.80 kg/ha) and potassium (169.25–206.57 kg/ha) were medium. In both open-field and alleys of 9-years old plantation, finger millet (variety '*VL-352*') was sown at 23×10 cm spacing, using seed rate of 7 kg/ha on 10.08.2018 and harvested on 4.11.2018. The gross plot size under guava, bael agri-horti system and open-field was 18.4, 9.0 and 9.0 m^2, respectively. Guava and bael tree was planted at 7×7 m distance. The millet grown under open-field recorded significantly highest growth (number of leaves/ plant and number of tillers/plant), yield attributes (number of productive tillers/plant, number of finger/ earhead) and yield (biological and grain yield) followed by guava agri-horti system. Lowest growth, yield attributes and yield was recorded under bael agri-horti system. The bael agri-horti system recorded lowest density and biomass broad-leaved weeds and density of total weeds as compared to guava agri-horti system and open-field. Further, among the weed management practices, HW twice recorded the lowest density and biomass of sedges, grasses and broad-leaved weeds. Simultaneously, HW twice recorded the higher plant growth attributes (plant height, dry matter accumulation, number of leaves and number of tiller/plant), yield attributes (number of productive tiller/plant, finger length, number of finger/earhead) and positively influence the yield (grain yield, biological yield and harvest index) of finger millet. Among the herbicidal treatments, isoproturon 0.75 kg/ha PE *fb* 1-HW was equally effective as HW twice, in enhancing most of the plant growth parameters (plant height, dry matter accumulation, number of leaves number of tiller), yield attributes (total number of productive tiller/plant, finger length, number of finger) of finger millet. Additionally, among herbicidal treatment, isoproturon 0.75 kg/ha PE *fb* 1-HW (30 DAS) recorded highest WCE. Thus, this study suggests that guava agri-horti system was compatible for finger millet production. Furthermore, under labour scarcity, isoproturon 0.75 kg/ha PE *fb* 1-HW (30 DAS) effectively manages weeds and enhance growth and yield of finger millet.

Evaluation of bio-efficacy of herbicide, atrazine 50% WP against major weed species in sugarcane with its phytotoxicity effect on sugarcane and residual effect on the succeeding cowpea crop

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A field trial was conducted during the two consequtive seasons of *Suru*-(spring planted) 2017 and 2018, at Regional Sugarcane and Jaggery Research Station, Kolhapur under Mahatma Phule Krishi Vidyapeeth, Rahuri to evaluate the effect of different rates of atrazine 50% WP in comparison with other herbicides and weed control practices in sugarcane. in randomized block design with three replications and eight treatments with the objective to find out the efficacy of atrazine 50% WP against major weed species in sugarcane variety *'Co 86032'*, its phytotoxicity effect on the same crop and residual effect on the succeeding Cowpea crop variety *'Gomati'* on the same layout of experimental sugarcane after sugarcane harvest. At 30 days after application (DAA), atrazine 50%WP 2000 g/ha was found significantly superior in weed control (density7.67/m^2) followed by diuron 80% WP 3200 g/ha (density 12.33/m^2) and 2,4-D dimethyl amine Salt 58% SL 3500 g/ha (17.33/m^2). Maximum weed count of 52.0/m^2 was recorded in control plot.At 45 DAA significantly minimum weed count was recorded in hand weeding plots (9.33/m^2), followed by atrazine 50%WP 2000g/ha (20.67/m^2) and Diuron 80% WP 3200 g/ha (24.0/m^2), which were statistically on par with each other. Next best was, 2,4-D dimethyl amine Salt 58% SL 3500 g/ha (32.33/ sq.m). Maximum weed count of 72.67/m^2 was in control plot (weedy check). At 60 DAA similar trend of 45 DAA was observed. Here, minimum weed count was in hand weeding plots (18.33/m^2) and it was significantly superior to all other treatments. Next best was atrazine 50%WP 2000 g/ha (26.33/m^2) and diuron 80% WP 3200 g/ha (30.67/m^2). Weedy check treatment recorded the maximum weed count of 95.33/m^2 Overall, atrazine 2000 g/ha attained better weed control efficiency at all the intervals of observations recording 85.98–100% at 15 DAA, 78.76–100% at 30 DAA, 65.52-100% at 45 DAA and 65.49-100% at 60 DAA, except against *Echinochloa colona*. *Ipomoea* spp and *Cyperus rotundus.* Weed control efficiency was the highest against *Xantheium strumarium* and *Cleome viscose.* The germination, plant population, number of millable canes & millable cane height, cane girth, brix and sucrose etc. were not differed significantly among the different herbicide treatments.. There was no any phytotoxicity symptoms, *viz.* leaf injury, necrosis, vein clearing, hyponasty and epinasty on sugarcane in any of the treatments. Plants were normal with respect to germination and other growth parameters indicating that atrazine 50% WP had no adverse effects on the crop even up to the dose of 4000g/ ha.The hand weeding treatment recorded the highest yield attributes as compared with other weed management treatments with significantly superior cane yield of 121.64 t/ha, followed by atrazine 50% WP 2000 g/ha (112.30 t/ha) and diuron 80% WP 3200 g/ha (107.47 t/ha) which are statistically on par. Lowest cane yield of 75.51 t/ha was recorded in control. The maximum weed control efficiency was observed in atrazine 50% WP formulation of 2000, 4000 g/ha, diuron (80% WP) 3200 g/ha and hand weeding treatments. Application of atrazine 50% WP at different doses and standard checks, diuron 80% WP 3200 g/ha and 2,4-D amine salt 58% SL 3500 g/ha did not cause any adverse effect on the succeeding crop cowpea with respect to germination, phytotoxicity at any growth stage and grain yield. Hence, pre-emergent application of atrazine 50%WP 2000 g/ha is the ideal dose for the effective management of all types of weeds in sugarcane crop and obtaining higher cane yield and it was safe to the succeeding crop of cowpea.

Tank mix application of halosulfuron-methyl and metribuzin against major weed flora of sugarcane in Cauvery Command Area of Karnataka

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Sugarcane is most important commercial crop in Cauvery Command Area of Karnataka and is grown in an area of 1.5 lakh ha. However, the productivity of cane in this region is very low 112.5 t/ha as compared to its potential yield. One of the main reason for low productivity is heavy weed infestation especially sedges in red sandy soil. The recommended pre- emergence herbicides in the region are atrazine and metribuzine, but both the herbicides failed to control sedges resulting in heavy infestation of sedges in sugarcane field. On the other hand, 2,4-D sodium salt was commonly used as post-emergence herbicide, but it controls only broad-leaved weeds and found ineffective against sedges. A field experiment was conducted during 2017-18 and 2018-19 at the Zonal Agricultural Research Station, V. C. Farm, Mandya to evaluate the bio-efficacy of tank mix application of halosulfuron-methyl + metribuzin against major weed flora of sugarcane. The soil of experimental site is red sandy loam with low in soil organic carbon (0.41%) and N (299 kg/ha); medium in P (45.3 kg/ha) and K (195 kg/ha). The treatments consisted of pre-emergence application (PE) of atrazine 2.5 kg/ha and metribuzin 1.5 kg/ha; post-emergence application (PoE) of 2,4-D sodium salt 2.5 kg/ha, ametryne 2.5 kg/ha and halosulfuron-methyl 90 g/ha + metribuzin 1.5 kg/ha PoE when weeds are at 3-4 leaf stage. These treatments were compared with weedy check and hand weeding thrice at 30, 60 and 90 days after transplanting (DAT). These treatments were replicated thrice in a complete randomized block design. The major weeds associated with sugarcane were *Echinochloa colona, Digitaria sanguinalis, Cynodon dactylon, Dactyloctenium aegyptium, Panicum repens*, among the grasses; *Parthenium hysterophorus, Potulaca oleracea, Commelina benghalensis, Trianthema portulacastrum, Boerhavia erecta, Euphorbia hirta, Corchorus trilocularis, Tridax procumbens, Phyllanthus niruri, Bidens pilosa* and *Ageratum conyzoides* among the broad-leaved weeds and *Cyperus rotundus,* the sedge. The two years pooled data indicated that halosulfuron-methyl 90 g/ha + metribuzin 1.5 kg/ha PoE was effective in the control of all types of weeds especially sedges and recorded significantly lower total weed density (7.85, 10.25 and 0.85 grasses, BLW and sedges/m^2) and weed biomass (4.58, 5.73 and 0.58 g/m^2 of grasses, BLW and sedges) at 30 days after application of herbicides and recorded 94.52% weed control efficiency. As a result of effective weed control the same treatment recorded significantly higher cane yield (182 t/ha) and B: C ratio (1:3.23) as compared to others. However, it was statistically at par with hand weeding thrice at 30, 60 and 90 DAT (188.52 t/ha). The uncontrolled weed growth throughout the cropping season reduced the cane yield by 56.6%. It was concluded that post-emergence tank mix application of halosulfuron-methyl 90 g/ha + metribuzin 1.5 kg/ha at 3-4 leaf stage of weeds is economically viable option to control weeds especially sedges in sugarcane.

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Non-chemical weed management in fenugreek

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Fenugreek (*Trigonella foenum-graecum* L.) is most valuable seed spices of semi-arid region of the country. In India, it is mainly grown in Rajasthan, Gujarat, Utter Pradesh and Tamil Nadu. Organic farming is a holistic production management system that enhances and sustains the health of soil, ecosystem and people. It emphasizes on ecological processes, biodiversity and other cycles adapted to local conditions. The yield of this crop lowered by many factors, among these weed infestation appears to be the most important one. Weeds have been identified as a serious constraints since they create the biotic stress in realizing the genetic yield potential of this crop. Weeds offered maximum competition up to 25-30 days of sowing in fenugreek resulting in drastic reduction in the seed yield. In organic farming, the use of herbicides is not permitted and therefore, non-chemical methods of weed control involving stale seedbed, soil solarization, mulching, crop rotation, intercropping and physical methods of weed control are the best alternatives and provide effective and acceptable weed control for realizing high production. However, complete control of weeds, especially in a mixed stand of annual and perennial weeds can't be achieved by using only one method alone in cropped fields. Many monocot and dicot weeds were observed in weedy check plot of the experimental fields. Bermuda grass [*Cynodon dactylon* (L.) Pers.], nut sedge (*Cyperus rotundus* L.), and wild onion (*Asphodelus tenuifolius* Cav.) among the monocots and sweet clover (*Melilotus alba* Medikus), clover [*Melilotus indica* (L. All.], Pimpernel (*Anagallis arvensi* L.), morning glory (*Convolvulus arvensis* L.), golden duck (*Rumax dentatus* L.), lamb squarters (*Chenopodium album* L.) and goose foot (*Chenopodium murale* L.) among the dicots predominated the experimental field. Application of plastic mulch followed by stale seed bed or soil solarization recorded significantly lower weed density. The plastic mulching treatments were at par and significantly superior over other treatments like stale seed bed *fb* interculture at 20 DAS *fb* mechanical weeding at 40 DAS and soil solarization *fb* inter culture at 20 DAS *fb* mechanical weeding at 40 DAS. Maximum weed control efficiency (100%) observed with stale seed bed technique *fb* plastic mulch at 60 DAS. Similar trends were observed in yields. Maximum seed and haulm yield of fenugreek were recorded with treatment of stale seed bed technique with plastic mulch, which was at par with plastic mulch with soil solarization. All the organic weed management treatments proved statistically superior over weedy check.

Effect of herbicides on weed dynamics and yield of finger millet

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Finger millet is considered as weapon against malnutrition because of its high nutritional value, is one of the important coarse cereal crops next to rice and wheat in Jharkhand. It is less expensive to cultivate. In India, finger millet is cultivated over an area of 1.38 million hectares with a production of 2.13 million tons giving an average productivity of 1.5 t/ha. The average yield of finger millet in Jharkhand state is much lower than the national average. Weed is one of the major constraints for attaining higher productivity of direct-seeded finger millet. Realizing weed problem in direct-seeded finger millet a study was carried out at Birsa Agricultural University, Kanke, Ranchi during rainy season of 2019 and 2020 in sandy loam acidic (pH 5.53) soil, with low available organic carbon (3.37%) and nitrogen (142.17 kg/ha), medium available phosphorus (18.55 kg/ha) and potassium (148.21 kg/ha). The objective of the study was to find out the most effective weed control methods in direct-seeded finger millet. The experiment was laid out inrandomized block design with three replications. There were 11 treatments, *viz*. pre-emergence application (PE) of oxadiargyl 150 g/ha + one inter cultivation (IC) at 25-30 days after seeding (DAS), oxadiargy l200 g/ha PE) + one IC at 25-30 DAS, bensulfuron-ethyl + pretilachlor 0.165 kg/ha PE + 1 IC at 25-30 DAS, bensulfuron-ethyl + pretilachlor 0.33 kg/ha PE + 1 IC at 25-30 DAS, butachlor 750 g/ha PE + one IC at 25- 30 DAS, post-emergence application (PoE) of bispyribac-sodium 10 g/ha 15-20 DAS + 1 IC at 35- 40DAS, bispyribac-sodium 15 g /ha PoE 15-20 DAS + 1 IC at 35-40 DAS, ethoxysulfuron 12 g/ha PoE 15-20 DAS + 1 IC at 35- 40 DAS, ethoxysulfuron 15 g/ha PoE 15-20 DAS + 1 IC at 35- 40 DAS, two inter cultivations with hand weeding (HW) at 20 and 40 DAS and un-weeded check. The finger millet variety *BBM-10* was sown at a seed rate of 8 kg/ha at 30 cm row spacing on 08th and 07th July and harvested on 22nd and 20th November during 2019 and 2020. Results of two years pooled data revealed that bensulfuron-ethyl + pretilachlor 0.33 kg/ha PE + 1 IC at 25-30 DAS has significantly reduced weed density to the extent of 92.69% and 84.07%, and weed biomass to the extent of 96.98% and 81.81% at 30 and 60 DAS compared to un weeded check and consequently, this treatment recorded significantly higher grain yield to the tune of 14.61% and 9.17% during 2019 and 2020 compared to usual practice of weed control two inter cultivations with hand weeding at 20 and 40 DAS, and 106.49% and 142.63% respectively, compared to un-weeded check. Hence, it can be concluded that, bensulfuron-ethyl + pretilachlor 0.33 kg/ ha PE + 1 inter cultivation (IC) at 25-30 DAS is better weed control option for realizing higher finger millet productivity.

Weed management in sugarcane with ready-mix post-emergence herbicides

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A field experiment was conducted at Agriculture Research Station, Hukkeri Dist Belagavi, Karnataka, India during 2018-19 and 2019-20 (Plant cane crop) to evaluate of bioefficacy and phytotoxicity of readymix post-emergence herbicides against weeds in sugarcane and its effect on succeeding crop**.** The experiment was laid out in a randomized complete block design and consisted of 8 treatments replicated thrice. The treatments were as follows: post-emergence application (PoE) of 2,4-D sodium salt 44% + metribuzine 35% + pyrazosulfuron-ethyl 1.0% WDG as post-emergence at 2500 g/ha 2,4-D sodium salt 44% + metribuzine 35% + pyrazosulfuron-ethyl 1.0% WDG 3000 g/ha PoE, topramezone 10 g/L + atrazine 300 g/L SC at 2500 ml/ha PoE, topramezone 10 g/L + atrazine 300 g/L SC at 3000 ml/ha PoE, pre-emergence application (PE) of atrazine 1000 g/ha followed by (*fb*) 2,4-D sodium salt 2000 g/ha PoE. 2,4-D sodium salt 2000 g/ha PoE, weed free check and untreated control. Weed density and biomass (grassy, sedge, BLW's and total) at 20, 40 and 60 days after herbicide spray (DAHS) were found to be significantly lower with 2,4-D sodium salt + metribuzine +pyrazosulfuron-ethyl 3000 g/ha PoE which was at par with topramezone + atrazine 3000 ml/ha PoE. Higher weed control efficiency was registered with 2,4-D sodium salt + metribuzine + pyrazosulfuron-ethyl 3000 g/haPoE (86.3, 74.5 and 72.79% at 20, 40 and 60 DAHS, respectively) followed by topramezone + atrazine 3000 ml/ha PoE (85.5, 73.3 and 70.47%, at 20, 40 and 60 DAHS, respectively). Pooled results of two years indicated significantly higher yield with 2,4-D sodium salt + metribuzine + pyrazosulfuron-ethyl 3000 g/ha PoE (137.5 t/ha) followed by topramezone + atrazine 3000 ml/ha PoE (132.5 t/ha). 2,4 D sodium salt + metribuzine + pyrazosulfuron-ethyl 3000 g/ha PoE recorded significantly higher gross returns (₹ 3,43,750/ha), net returns (₹ 2,56,450/ha) and B:C ratio which was on par with topramezone + atrazine 3000 ml/ha PoE (₹ 3,31,250/ha,₹ 2,44,750/ha and 3.83, respectively). Different herbicide treatments showed non significant influence on dehydrogenase activity at 120 days after planting and at harvest. Phytotoxicity was not observed due to application of readymix herbicides on plant cane and on succeeding cowpea crop. As sugarcane is a long duration irrigated crop and labour availability is becoming scares, these ready-mix herbicides can be better alternatives to recommended single formulation herbicides and weed free check in plant cane.

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Integrated weed management in taro

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Taro (*Colocasia esculenta* L.) is a vegetative propagated tropical tuber crop, originated from South-East Asia. It is an important tropical tuber crop next to cassava, sweet potato and yams, occupies 9th position among world food crops. It is cultivated in an area of 1.72 million hactares, 12.84 million tons at global level. Taro is grown primarily for its edible corms and cormels, and leaves. It is widely cultivated in the high rainfall areas under flooded condition to upland areas with additional irrigation by small farmers.An experiment was conducted in taro to find out an effective method of weed management. The experiment was laid out in randomised block design with 8 treatments and 3 replications, at ICAR- Central Tuber Crops Research Institute, Kerala during 2020 and 2021. High yielding taro variety '*Muktakeshi'* with approximate crop duration of 165 days was used for the study. The use of perforated weed control ground cover mat (nursery men mat 120 gsm thickness) is conducive to the growth of the crop and recorded higher plant height, number of leaves per hill, and leaf area index at 2 and 4 months after planting compared to the rest of the treatments, and recorded less weed density, biomass of the weeds. The predominant weed species in this crop were: *Cyanodon dactylon* (L.) Pers. *Setaria glauca* (L.) Beauv., *Pennisetum polystachion* (L.) Schultes, *Pennisetum pedicellatum* Syn. *Cenchrus pedicellatus* (Trin.) Morrone, *Mimosa pudica* L., *Indoneesiella echioides* L., *Euphorbia hirta* L., *Alternanthera paronychioides* A. St. Hil., *Atylosia scarabaeoides* (L.) Benth. Next best treatment for higher plant growth and lower weed biomass was weed free followed by post-emergence application (PoE) of quizalofop-ethyl at 20 days after planting and two sprays of glyphosate at 60, 90 days after planting. Among weed management practices, perforated weed control ground cover mat recorded significantly higher yield of corms (8.0, 7.54 t/ha), cormels (20.92, 18.31 t/ha), total yield (28.92, 25.85 t/ha), higher gross and net returns and B:C ratio (2.77, 2.76) than the rest of the treatments in the year 2020 and 2021 respectively. Weedy check (control) recorded yield loss of 79% and 85% during 2020 and 2021, respectively. Based on the experimental findings of both the seasons, it is recommended that weed control ground cover is the best for controlling weeds and for higher yield.

Integrated weed management in coriander and residual effect of herbicides on succeeding greengram crop

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Coriander is an important seed spice crop which is popular in tropical and sub-tropical regions for its seed and tender leaves as food additive. India is the largest producer and acreage holder of coriander in the world. In recent past area under coriander is also increased significantly in arid and semi-arid regions of Gujarat, because of ever increasing demand, low requirement of costly inputs and higher market price as compared to other *Rabi* crops. Heavy weed growth appears to be the most serious menace in realizing the full yield potential of coriander. The traditional method of broadcast sowing and delay in germination with initial slow growth rate increases weed competition at early stage resulted into reduction in seed yield. Manual control of weeds is tedious, time consuming and labour intensive. Recognition and employ of a selective (Pre as well as early post) herbicide is the best alternative to control weed effectively but it creates soil-air-water pollution and may increase residues in or on the seed. Integration of physical with chemical method of weed control is the cost effective, reduce the load of residues and manage the weed effectively. Threfore, an experiment on the integrated weed management in coriander and residual effect of herbicides on succeeding greengram crop, was undertaken during the years *Rabi* 2018 and 2019 at Seed Spices Research Station, S.D.Agricultural University, Jagudan. The experiment comprise d of ten treatments *viz*, unweeded control, inter cultivation (IC) + hand weeding (HW) at 20 and 35 days after seeding (DAS), pre-emergence application (PE) of pendimethalin 1.00 kg/ha, pendimethalin 1.00 kg/ha PE followed by (*fb*) IC and HW at 30 DAS, oxadiargyl 100 gm/ha PE, oxadiargyl 100 gm/ha PE *fb* IC and HW at 30 DAS, pendimethalin 0.500 kg/ha + oxyfluorfen 30 g/ha (tank mix) PE, oxadiargyl 100 g/ha as early post-emergence (EPoE) at 7-10 DAS, oxadiargyl 100 g/ha EPoE at 7-10 DAS *fb* IC and HW at 35 DAS, weed free up to harvest, replicated thrice in randomized block design. All standard packages of practices were followed throughout the cropping season. Observations were recorded on weed parameters, growth parameters, yield attributes and yield. For the study of residual effect of herbicides, greengram was grown and phytotoxicity observations were recorded up to three leaf stage. The minimum growth and yield attributes were recorded under unweeded control. Treatments weed free, inter cultivation (IC) + hand weeding (HW) at 20 and 35 days after seeding (DAS), pendimethalin 1.00 kg/ha PE followed by (*fb*) IC and HW at 30 DAS and T_7 were statistically equally effective in recording coriander growth and yield attributes which were significantly higher than recorded with treatments oxadiargyl 100 g/ha as early post-emergence (EPoE) at 7-10 DASand unweeded control on pooled basis. Maximum seed coriander yield was recorded with weed free up to harvest (993 kg/ha) and was at par with treatments inter cultivation (IC) + hand weeding (HW) at 20 and 35 days after seeding (DAS) (976 kg/ha) and pendimethalin 1.00 kg/ha PE followed by (*fb*) IC and HW at 30 DAS (935 kg/ha), while significantly superior over rest of the treatments. These treatments reduced the weed crop competition for resources resulting in increased growth and yield attributes ultimately seed yield. Significantly highest total weed density was recorded with treatment unweeded control, while inter cultivation (IC) + hand weeding (HW) at 20 and 35 days after seeding (DAS) and weed free recorded significantly lower total weed density than rest of the treatments on pooled basis. Significantly maximum (1265 kg/ha) and minimum (10 kg/ha) weed biomass was recorded with unweeded control and weed free, respectively. Irrespective of weed free treatment, treatment inter cultivation (IC) + hand weeding (HW) at 20 and 35 days after seeding (DAS) secured higher WCE (89%) followed by treatments pendimethalin 1.00 kg/ha PE followed by (*fb*) IC and HW at 30 DAS (87%),oxadiargyl 100 g/ha EPoE at 7-10 DAS *fb* IC and HW at 35 DAS (85%) and toxadiargyl 100 gm/ha PE *fb* IC and HW at 30 DAS(84%). The effective weed management treatments did not cause any harmful effect on germination of succeeding greengram crop.

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Weed flora of cotton – A review

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Cotton, being a long duration, widely spaced and relatively slow growing crop during early growth stages, is subjected to severe weed menace. Weed infestation in cotton has been reported to offer severe competition and causing yield reduction to an extent of 40 to 85%. Weeds which emerge with cotton plants offer a severe competition and bring about considerable reduction in seed cotton yield. Reduction in seed cotton yield under irrigated conditions is primarily due to nutrient depletion caused by weeds and may vary over from 10-90 per cent. Weeds are considered as a major biotic constraint for high production. The weeds which germinate before or simultaneously with the crop are frequently capable of forming a leaf canopy over cotton. Late emerging weeds may interfere with cotton defoliation and harvest and may lower lint grade due to lint staining and to excessive foreign material. Knowing the weed species that are a problem in cotton fields and developing an appropriate weed control strategy is inevitable for sustainable cotton production. The first step in weed control is the identification of weeds. Identified weeds should be recorded. The characteristics of the weeds found should be studied.. It is important to understand the biology, such as its life cycle and reproduction and the ecology related to their spread and adaption. To evolve a successful weed control programme, identifying and understanding of weed community associated with cotton crop is essential. Weed flora differ widely in their diversity depending upon environmental and soil conditions and hence the information on the weed spectrum of appropriate and cotton fields is essential for the formulation of effective weed management practices. Weed flora of a location vary depending upon soil type and environment.The predominant weed flora of cotton are *Abutilon indicum*, *Amaranthus viridis*, *Amaranthus spinosus*, *Boerhaavia diffusa* (L.), *Cleome viscosa* (L.), *Commelina benghalensis* (L.), *Corchorus olitorius*, *Datura fastuosa*, *Digera arvensis*, *Euphorbia prostrata*, *Flaveria australasica*, *Parthenium hysterophoru*, *Portulaca oleracea* and *Trianthema portulacastrum*,grasses namely: *Chloris barbata*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Echinochloa colona* and *Panicum repens* and the sedge weed was *Cyperus rotundus*. The period of weed interference, crop damage and the critical time of crop-weed competition were established as 30 to 90 days, which is about 50 per cent of the whole cotton growing period. Cotton plant establishment, height, biomass, square and boll number of cotton were significantly affected by weed competition. Critical period of weed competition occurred between planting and the 3-leaf stage of cotton minimized yield loss to five per cent. Competition for light may commence very early in cropping season if a dense weed growth smothers the crop seedlings. The crop like cotton is prone to heavy weed growth at seedlings stage and finally suffer due to shading effect of weeds. Therefore, proper identification of weed species prevailing in the field is essential for implementing any weed control programme successfully.

Effect of various weed control treatments on different weed species of Mentha spp. under Punjab Conditions

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Crop plants are often hindered and stunted by weeds, which interfere with their functions and stunt their growth. The major crops grown throughout the world suffer yield losses caused by weeds by 34%. There is a higher yield loss caused by weeds in comparison with other pests. A study of various weed control treatments was therefore conducted under Punjab conditions to find out how they affect different species of mentha. The field experiment was conducted during the spring season of 2019 at the Agriculture Research Farm, Lovely Professional University, Phagwara (31°152 N, 75°422 E and altitude 235 m). The soil of the experimental site was slightly alkaline, having pH 7.6, organic carbon 0.42% (low), available N 185.0 kg/ha (low), available P 12.6 kg/ha (medium), and available K 252 kg/ha (medium). Monthly average of maximum temperature was obtained to be 36.8°C and minimum of 24.6°C and average rainfall was 75.38 mm respectively during the growing season. The experiment was carried out in RCBD (Randomized Complete Block Design) with three replications and three species of mentha *i.e., Mentha piperita, Mentha arvensis* and *Mentha spicata* and 15 treatments comprised of control, hand-weeding, Agil herbicide, Basagran herbicide and sulfosulfuron herbicide commonly used for all species. Weeds namely *Cyperus rotundus, Chenopodium album, Rumex dentatus, Eleusine indica, Digitaria sanguinalis* were the major part of weed flora. At 120 DAS, hand weeding recorded a minimum total weed density of *Chenopodium album, Rumex dentatus,* and *Digitaria sanguinalis i.e.,* 6.5% less than control. However, 4.4% reduction in populations of *Eleusine indica* and *Cyperus rotundus* was seen in treatments with Agil and sufosulfuron as compared to control. *Mentha arvensis* had the lowest weed dry matter (1.93 t/ha) at 120 DAS, although *Mentha piperita* and *Mentha spicata* had statistically similar weed biomass levels. The hand weeding treatment had the least amount of weed biomass, followed by the Agil and Basagran treatments, and the control treatment had the highest amount of weed biomass. All the weed control treatments were effective in reducing the weeds. Hand-weeding, Agil, and sulfosulforon were used effectively to reduce weed populations and dry matter, however, sulfosulforon showed phytotoxicity against certain *Mentha* species.

Efficacy of different weed management practices on weed density and seed yield of dill (*Anethum graveolens* L.)

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Dill is a fragrant and therapeutic annual herb of the *Apiaceae* family. It is commercially grown in Rajasthan, Gujarat, Maharashtra, AP and MP. Weed control is an important practice to increase crop production. As the initial growth of the crop is slow so it's important to keep the field clean and weed-free to reduce the weed menace either through pre- or post-emergence application of herbicides or by inter-culturing or hand weeding.This field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during the *Rabi* 2021-22. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction, medium in organic carbon, available nitrogen and phosphorus but high in potassium. The experiment consisted of thirteen treatments ***i.e***., pendimethalin 1000 g/ha PE, pendimethalin 750 g/ha PE *fb* HW at 40 DAS, pendimethalin 750 g/ha PE *fb* quizalofop-ethyl 40 g/ha PoE, oxadiargyl 100 g/ha PE, oxadiargyl 75 g/ha PE *fb* HW at 40 DAS, oxadiargyl 75 g/ha PE *fb* quizalofop -thyl 40 g/ha PoE, oxadiargyl 50 g/ha PoE, oxyfluorfen 100 g/ha PE, oxyfluorfen 75 g/ha PE *fb* HW at 40 DAS, oxyfluorfen 75 g/ha PE *fb* quizalofop-ethyl 40 g/ha PoE, IC *fb* HW at 20 and 40 DAS, oxadiargyl 50 g/ha + propaquizafop 50 g/ha PoE and weedy check which were laid out in RBD and replicated thrice. The Ajmer *Sowa-1* variety was used for the study.The experimental field at 60 days after sowing (DAS) was infested with both grassy as well as broad-leaved weeds like *Chenopodium album* L. (22.9%), *Chenopodium murale* L. (19.86%), *Fumaria parviflora* L. (9.92%), *Malva parviflora* L. (10.80%), *Melilotus indica* L. (15.21%), *Convolvulus arvensis* L. (5.70%) and *Phalaris minor* Retz. (15.57%). Data indicated that at 60 DAS compared to weedy check, all the weed management treatments significantly reduced the weed density. The treatment oxyfluorfen 75 g/ha PE *fb* HW at 40 DAS (1.01 no./m^2) recorded the lowest weed density of grassy weeds which was at par with IC *fb* HW at 20 and 40 DAS (1.05 no./m^2), oxyfluorfen 100 g/ha PE (1.13 no./m^2) and oxadiargyl 75 g/ha PE *fb* HW at 40 DAS (1.17 no./m^2). While the lowest broad-leaved and total weed density was found with IC *fb* HW at 20 and 40 DAS (5.43 no./m^2, 6.47 no./m^2). The highest seed yield was witnessed in IC *fb* HW at 20 and 40 DAS (1.19 t/ha) which was at par with oxadiargyl 75 g /ha PE *fb* HW at 40 DAS (1.16 t/ha) and oxadiargyl 100 g/ha PE (1.14 t/ha) over the weedy check. Therefore, from the study, it can be concluded that for effective control of weeds along with higher yield could be achieved either by pre-emergence application of oxadiargyl 75 g/ha followed by HW at 40 DAS, oxadiargyl 100 g/ha PE or IC *fb* HW at 20 & 40 DAS for dill crop grown in sub-humid regions of Southern Rajasthan.

Weed management in foxtail millet with pre- and post-emergence herbicides

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Foxtail millet (*Setaria italica* (L.) Beauv) is one of the world's oldest cultivated crops. Foxtail millet is grown as rainfed crop in India and like other *Kharif* annuals. Severe weed infestation is noticed in foxtail millet due to its slow growth at initial stages and as it is grown during rainy season. Pre-emergence herbicides improve the weed control and production efficiency in major millets due to their bigger seed size and comparatively deeper depth of sowing than small millets. The research on herbicides evaluation tomanage weeds in foxtail millet is very meagre. Currently, as the cost of hand weeding is increasing and farmers are inclining to use herbicides in small millet crops for effective control of weeds. Hence, this study was undertaken to assess the efficacy of pre-emergence application (PE) of herbicide supplemented with intercultivation or post-emergence application (PoE) of penoxsulam for weed control with better selectivity in foxtail millet in a randomized block design with three replications on sandyloam soils of Tirupati, Acharya N G Ranga Agricultural University. Eleven weed management treatments consisted of: pre-emergence application (PRE) of pretilachlor, isoproturon and pyrazosulfuron-ethyl 500, 500 and 15 g/ha, respectively. All the pre-emergence herbicides were supplemented with intercultivation or post-emergence application (POE) of penoxsulam 20 g/ha at 20 days after seeding (DAS); hand weeding (HW) twice and unweeded check. Pre-emergence herbicides were applied at 1 DAS and intercultivation / post-emergence herbicide, penoxsulam was applied at 20 DAS. The predominant weed flora associated with foxtail millet was *Digitaria sanguinalis* (L.) Scop. (42%), *Cyperus rotundus* L. (22%), *Cucumis callosus* (9%), *Boerhavia erecta* L. (6%), *Commelina benghalensis* L. (5%), *Cynodon dactylon* (L.) Pers. (5%), *Borreria hispida* (L.) K. Schum. (3%), *Cleome viscosa* L. (3%) and others (5%). Among the weed management treatments tested, the lowest density and biomass with higher weed control efficiency were observed with pretilachlor 500 g/ha PE followed by (*fb*) intercultivation at 20 DAS which was comparable with pyrazosulfuron-ethyl 15 g/ha PE *fb* intercultivation at 20 DAS and isoproturon 500 g/ha PE *fb* intercultivation at 20 DAS which might be due to broad-spectrum and season long weed control. However, all these treatments were significantly less effective in reducing weed growth than HW twice at 20 and 40 DAS. Application of PE herbicides at their respective doses supplemented with PoE application of penoxsulam 20 g/ha registered significantly higher density and biomass of weeds, among the herbicidal treatments. Significantly higher number of panicles / m^2, weight of the grains / panicle, grain and straw yield were recorded with HW twice and it was closely followed by pretilachlor 500 g/ha PE *fb* intercultivation at 20 DAS. The decrease in grain and straw yield due to heavy weed infestation in unweeded check was 63.42 and 26.95%, respectively, compared to best weed management practice. Among all the weed management treatments, the highest benefit-cost ratio was realized with pretilachlor 500 g/ha PE *fb* intercultivation at 20 DAS and it was closely followed by pyrazosulfuron-ethyl 15 g/ha PE *fb* intercultivation at 20 DAS.

Florpyrauxifen-benzyl for the management of aquatic weeds in wet land rice

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The below sea level farming system of Kuttanad, Kerala, India, was recognized as Gobally Important Agricultural Heritage System by FAO in 2013.It has a unique rice-based cropping systems. In these reclaimed rice fields, cultivation is done by draining water at the time of sowing to the surrounding water bodies which ultimately reaches the Vembanad Lake. Major aquatic weeds in the area include *Eichhornia crassipes*, *Salvinia molesta*, *Cabomba caroliniana*, *C. furcata*, *Pistia stratioites*, *Utricularia escoleta*, *Chara vulgaris*, *Ipomoea aquatica, Nymphaea stellata*, *Limnophylla heterophylla etc*. Invasion and spread of major aquatic weeds *viz*. *Eichhornia crassipes*, *Salvinia molesta*, *Nymphaea stellata* in the water bodies and its proliferation through seed and offshoots in the lowland rice fields during non-cropped situation affects land preparation, sowing and crop establishment in Kuttanad. Thick mat of the aquatic weeds hinder machinery operation for tillage, puddling and transplanting. Though management by mechanical aquatic weeders is possible, it is too expensive in large paddy polders. Repeated tillage to destroy these weeds not only destroys all the advantages of stale seed bed preparation adopted by the farmers to reduce soil seed bank but also adds to the cost of cultivation and delays the crop. The present practice of large-scale application of broad-spectrum herbicides like paraquat dichloride, glyphosate, 2,4-D *etc*., into the water bodies for management of aquatic weeds has to be prevented for eco-friendly rice farming. Hence, a study was undertaken to evaluate the efficacy of florpyrauxifen-benzyl 2.5% EC for the control of *Eichhornia*, *Salvinia* and *Nymphaea* as pre-sowing application in rice and to study the phytotoxicity of florpyrauxifen-benzyl in rice, if any. The experiment was conducted in puddled direct- wet-seeded rice (WSR) where herbicides were applied as pre-sowing application during *Kharif* seasons of 2020 and 2021. Various doses of florpyrauxifen-benzyl 12.5, 15, 17.5, 20.0 g/ha and phytotoxic dose of 40 g/ha were applied in the rice fields 30 days prior to wet-seeding of rice. The tested herbicide was compared with 2,4-D Na salt 1480 g/ha. The results revealed that pre-sowing application of florpyrauxifen-benzyl 17.5 - 20.0 g/ha after draining water from the paddy polders can provide broad-spectrum management of small and medium sized bulbous *Eichhornia* and medium sized *Nymphaea and Nymphoides*. The results obtained at florpyrauxifen-benzyl 20.0 g/ha were equally effective as 2,4-D Na salt 1480 g/ha for the management of small and medium sized bulbous *Eichhornia*. For the management of *Nymphaea*, florpyrauxifen-benzyl 17.5 g/ha was sufficient to give result as that of 2,4-D Na salt 1480 g/ha, provided the field is drained immediately after herbicide application. Drained condition of rice field is essential for getting best results on application of the tested herbicide. Weed control efficiency (WCE) of florpyrauxifen-benzyl at 21 days after application (DAA) for the management of *Eichhornia* at 17.5 g/ha and 20.0 g/ha was 58% and 75%, respectively. While for *Nymphaea*, WCE at 21DAA was 75% in florpyrauxifen-benzyl 17.5 g/ha and 70% in florpyrauxifen-benzyl 20.0 g/ha. Florpyrauxifen-benzyl applied as pre-sowing application was not effective for the management of *Salvinia molesta* in rice fields. While, *Nymphoides indica* was completely destroyed even at the lower dose of florpyrauxifen-benzyl 12.5 g/ha. There was no phytotoxicity in the succeeding puddled direct wet-seeded rice crop due to pre-sowing application of florpyrauxifen-benzyl 17.5-20.0 g/ha.

Dragon scale fern (*Pyrrossia* sp.), a problematic epiphyte fern in plantations of Periyar river basin in Kerala

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Pyrrossia species commonly known as Dragon scale fern and in Malayalam as "Sita Tali or Kurukkan Tali" is a fast-spreading troublesome epiphyte fern in the Periyar river basins of Kerala. It is a crassulacean acid metabolism (CAM) plant belongs to the family Polypodiaceae. Being a CAM plant, it is very much tolerant to adverse climatic conditions like elevated temperature and carbon dioxide. An investigation was conducted under Kerala state plan project 2019-20 to study the extend of infestation of the epiphytic fern. It is a creeping fern having special root characteristics with network of root hairs which adhere close to the host branches. The leaves are arranged alternatevely, oval in shape and fleshy in nature which can conserve water for long time is a distinct characteristic of the fern help to survive in water deficient conditions also. Both fertile and sterile fronds are seen and the sorii or spores are arranged on lower side of the fertile frond turns brownish upon maturity. As this fern reproduce through spores it can spread rapidly from one tree to another. Survey was conducted during 2019-2022 in the nutmeg plantations and other homesteads in the Periyar river basins of Kerala. It was observed that *Pyrrossia* infest trees such as nutmeg (*Myristica fragrans*), mango (*Mangifera indica*), jack tree (*Artocarpus heterophyllus),* sapota (*Manilkara zapota*), tamarind (*Tamarindus indica*), coconut (*Cocos nucifera*), arecanut (*Areca catechu*), cocoa (*Theobroma cacao*) and other trees such as teak (*Tectona grandis*), banyan tree (*Ficus benghalensis*), golden shower tree (*Cassia fistula*), wild jack (*Artocarpus hirsutus*), punna tree (*Calophyllum inophyllum*), suicide tree (*Cerbera odollam*). After the Kerala flood 2018, this epiphyte fern was found to be a serious problem in the river basin. High moisture and shaded situations of the river basin was found to be conducive for the fast growth of the fern along with other fungal diseases. It was also observed that there is difference in severity of infestation between the host plants, found more in nutmeg. The twigs or branches of the trees are densely grown with the fern and severely infested twigs are seen dried whereas infested main branches or tree trunk are not seen apparently affected. Infestation of *Pyrrossia* leads to fungal attack on the host plants ultimately causes defoliation and death of the plants. The fern causes defoliation and death of host tree-branches, and the decline of host plant growth is caused by mycorrhizal fungi of epiphytes, which act as pathogen for host plants. *Pyrrossia* harms its host by smothering its growth. The manual eradication was laborious as the rhizomes adhered strongly to the branches and the fern spread throughout deep in the canopy.

Does change in carbon dioxide level influence salinity tolerance to Parthenium?

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Climate is a major factor in earth's environmental system. A continuous warming trend is happeningin the climate of the earth. It is projected to cause the global surface temperature to rise from 1.4 to 5.8°C by the end of the 21st century. Major source of global climate change is carbondioxide (CO_2) and its concentration is predicted to reach 700 ppm by the end of the twenty- first century. Rising CO_2 concentration is the major cause for climatic variation. Weed biology, spread and management of invasive weed species are being influenced by the varitation in the global climate. Climate change influences the invasive species reproduction behaviour and its invasion potential. *Parthenium hysterophorus* is considered as one of the "100 most invasive species in the world" by the International Union for Conservation of Nature (IUCN). It s a most aggressive herbaceous short-lived weed of global significance. Globally parthenium is known as feverfew or ragweed, and invaded the fields of major crops like wheat, rice, sorghum, maize, and pastures, and it also grows in vacant land, disturbed sites, roadsides, railway tracks sides and wastelands. The pollen grains of parthenium can cause severe contact dermatitis, hay fever (allergic rhinitis) and aggravated asthma (allergic bronchitis) in human beings. *P. hysterophorus* benefits from the elevated CO_2 concentration by improving its photosynthetic efficiency due to its C_3 pathway throughout its life cycle except during the early rosette stage of the weed. Sole source of carbon for the plant is CO_2, and elevated CO_2 concentrations influence photosynthesis and stomatal conductance. Salinity is assuming as major abiotic stress apart from elevated temperature and CO_2. A soil is saline when its electrical conductivity of saturation extract (ECe) is above $4dSm^{-1}$. An elevated CO_2 concentration in the atmosphere aid the plant species to invade new areas by tolerating salinity. While most studies focused either on responses to elevated atmospheric CO_2 concentration and/or salt stress to cultivated plant species, there is dearth of research literature on *P. hysterophorus*, an invasive weed species. Therefore, it is needed to assess the combined effects of salinity and elevated CO_2 on germination and growth of *P. hysterophorus*. A study was undertaken during 2018 under controlled environmental conditions at the Gatton campus of the University of Queensland, Australia to understand the influence of varied levels of soil salinity (0, 4, 8, 12, and 16 dSm^{-1}) on the early growth of *P. hysterophorus* at an ambient (400 ppm) and an elevated concentration (700 ppm) of CO_2. The objective of this study was to find the tolerance behaviour of *P. hysterophorus* to varied levels of salinity under elevated atmospheric CO_2 concentration. The findings of this study clearly indicates that *P. hysterophorus* has the ability to germinate under relatively high salt concentrations. The elevated [CO_2] level improved the parthenium growth at all salinity levels. The findings of this study would help to devise a management strategy in preventing *P. hysterophorus* to invade new areas of higher soil salinity.

Predicting the potential risk of littleseed canarygrass (*Phalaris minor*) in India under future climatic scenarios

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Littleseed canarygrass (*Phalaris minor* Retz.) is a competitive invasive annual weed native to the Mediterranean region. It has infested more than 60 countries of the world including all continents except polar region. In India, the weed has evolved resistance to most commonly used herbicides, and thus, emerging as a major threat to wheat cultivation in rice-wheat system of Indo-Gangetic Plains. In the present study, maps depicting the current geographical distribution and habitat suitability of *P. minor* under RCP 4.5 and 8.5 for 2050 and 2070 were obtained using MaxEnt program. These were obtained using bioclimatic variables along with soil and Shuttle Radar Topography Mission (SRTM) elevation data as independent parameters over occurrence location of the species. The occurrence records with geo coordinates were collected from secondary sources. The climatic variables were collected from www.worlclim.org site at 30 arc seconds (900 m^2) resolution. Out of 19 bioclimatic variables, eight were chosen for the analysis having least mutual correlation over the study area. Accuracy and validation of the models were checked using Area Under the Receiver Operating Characteristic (ROC) Curve (AUC) obtained using test data in MaxEnt. AUC values ranges from 0 to 1. Jackknife test was employed to check the relative significance of different environmental/input variables. The average test AUC value for model built using current occurrence data was 0.798 with standard deviation of 0.044. Results revealed that the environmental variable with highest gain when used in isolation is bio4 (temperature seasonality), which therefore appears to have the most useful information by itself and explains distribution of *P. minor*, the most, followed by bio6 (min temperature of coldest month) and bio1 (annual mean temperature). Using the occurrence data and environmental variables including elevation and soil layers, current distribution maps of *P. minor* were obtained and prepared in four classes of climate suitability *i.e.* not suitable (0-0.25), low (0.25-0.50), moderately (0.50-0.75) and highly suitable (>0.75) categories. Results also revealed that high suitable conditions (>0.75) for *P. minor* are characterized by annual mean temperature (bio1) at 24°C which favours the establishment of species most in these areas. Northern part of India was found to be potential hotspot for this species in current climatic conditions. Northern states such as Punjab, Haryana, Uttar Pradesh and some parts of Bihar and Rajasthan fall under highly suitable area category. However, an overall decrease in climate suitability for this species was found under future climate scenarios for 2050 and 2070 under RCP 4.5 and 8.5. This leads to the conclusion that future climatic conditions are not favourable for *P. minor* and may lead to a diminution in species invasiveness and also its shift to newer area.

Evaluating the impact of *Lantana camara* removal on native biodiversity, regeneration status and soil quality in three agro-climatic zones of Chhattisgarh

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Lantana camara L., one of the highly invasive weeds has threatened native biodiversity, prevented ecological succession, changed community structure and impacted ecosystem services in forest ecosystems across India. Although attempts inside forest areas have been made to control invasive weeds through different mechanical methods, there is hardly any success in its control or prevention. Lack of effective management strategies has aggravated the ecological crisis in forested landscapes. States in India have largely followed (a) cut rootstock method, (b) slash-burn method and (c) hand pulling/ uprooting method to suppress the spread of these invasive weeds. Chhattisgarh state, which has a forest cover of 55716.6 sq. km. occupying 41.21% of its geographical area faces severe invasion by *L. camara* in its major and sub forest types. State Forest Department (SFD) of Chhattisgarh manually cleared vast stretches of *L. camara* invaded forested lands to the tune of 2.58 lakh hectares area in a phased manner from different forest types during the period 2018-2021. In these stretches, a study is being undertaken to assess the impact of *L. camara* removal operation on native biodiversity, regeneration status, soil physical and chemical status, soil micro fauna and seed bank status, and NTFP/medicinal plants collection. Study area is spread along the three agro climatic zones of the state *viz.*, Balrampur (Northern hilly zone), Marwahi (Chhattisgarh plains zone) and Bastar (Bastar plateau zone). Based on the intensity of *L. camara* invasion, the sites were categorized into high, medium and low in each division. Thereby, six (three treated and three control) 1-ha (100 m × 100 m) square plots were laid in each of the forest divisions. Borders of the 1-ha plot were permanently marked with aluminum tags so as to enable subsequent surveys. Soil samples for physico-chemical analysis were tested within the 1-ha square plot at three depths viz. 0-15cm, 16-30 cm and 31-45 cm. The study which is in its first phase of assessment, has revealed that significant area removed off *L. camara* facilitated regeneration of seedlings of existing native trees particularly *Shorea robusta*, while few compartments of different forest ranges had resurgence of *L. camara* from the existing seed bank in the treated plots (*L. camara* removed plots). Secondary colonization of the treated plots by *Chromolaena odorata* was also found which established inter specific competition between invasive alien weeds in pristine forested ecosystems. Analysis of soil samples from Marwahi forest division (Chhattisgarh plains zone) in both treated and control forests of medium infestation density revealed that *L. camara* invasion significantly altered the pH, and nutrient content of the ecosystem. The study revealed that, while *L. camara* increased total nitrogen availability in the soil, the weed removed plots showed increased concentration of available phosphorus and potassium than control plots, implying that *L. camara* invasion limit the growth of competing species in the same ecological niche by physiologically starving them for nutrients. These forest areas of Chhattisgarh are prime habitats for wildlife, *Shorea robusta* (Sal) trees and other mixed-deciduous forest species, and are also home to forest dependent communities. In this context, the current study to assess the impact of *L. camara* removal strategy will have positive implications in not only the conservation and management of forest resources in the state of Chhattisgarh, but also in various long-term *L. camara* eradication programs in India.

Approaches for integrated weed management system

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In recent years, the impact of invasive alien weeds on biodiversity has become a major concern. The silent green invaders constantly encroach into parks, preserves, wildlife refuges, forests and urban spaces affecting native biota and eventually resulting in thousands of extinctions. While the economic costs of biological alien invasions are enormous, the ecological cost is irretrievable loss of native species and eco-systems. The management of the alien weed invasions is a serious challenge as they mostly occur in non agricultural waste lands which nobody cares for. Weed control practices in forests are designed to favour the growth of the desired tree species, improve visibility along roads, control noxious weeds, and improve wildlife habitats. The goal is to manage timber species, ground vegetation, and wildlife so that each component is maximized yet balanced. Vegetation management is a primary means to achieve productive forests. Managers need to integrate the best cultural, mechanical, and chemical practices into appropriate and cost-effective management systems to minimize losses and detrimental effects due to weeds. The type and intensity of management practices depend on the vigor of the desired species and the indigenous species. Early detection of incipient invasions and quick coordinated response are needed to eradicate or contain invasive species before they become widespread and control become technically and / or financially impossible. Integrated weed management is the coordinated use of variety of control methods, reducing reliance on herbicides alone, and increasing the chances of successful weed management or eradication. Integrated weed management programme requires long term planning, knowledge of weed's biology and ecology and appropriate weed control methods. Thus, six main strategies for dealing with the management of invasive alien weeds are eradication through biological control *i.e.* inundative and classical, streaming *i.e.* applying hot water by plumbing water under pressure, mulching *i.e.* use of physical barriers such as black plastic of woven weed matting or uses of natural mulches such as saw dust, timber chips, straw, manures and grass clippings, fire, herbicides, reforestation and land management. Successful integrated management plans incorporate the right package of practices into well planned programme that are executed on a timely basis. No single plan is best suited for each site, so careful analysis of each site is necessary. Routinely review the results obtained and modify the plans as needed to ensure satisfactory control. After using any vegetation / integrated control practice, inspect the area to evaluate the results. Keep in mind the type and species of vegetation treated; the soil type, and weather conditions during and after application. Know the objectives of the control programme when evaluating the results. In some cases, suppression of treated vegetation is sufficient; in others, selected control is desired. The results of vegetation control treatments should be evaluated after about two months, at the end of season, and then for several years. The effectiveness of bushes and perennial weeds control measures cannot be fully evaluated for at least 12 and sometimes 24 months after treatment. Evaluation must be an ongoing activity. It allows you to make adjustment in rates, products, and timing of herbicides application, and to plan any additional control measures that may be needed.

Impact of invasive shrub, *Lantana camara*, removal on biological properties of soil in Chhattisgarh Forest

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Invasive plants are commonly recognized to have severe ecological impacts in a wide range of ecosystems throughout the world. They can alter ecosystem structure and function, trophic structure, resource availability and downgrade biodiversity of natural landscapes. The success of *Lantana camara* distribution throughout the Indian subcontinent is a reflection of its wide ecological tolerances. The invasive alien species *L. camara*, has invaded the major and sub forest types in Chhattisgarh. Weed removal experiments provide strong evidence for weed impacts, validating management techniques and demonstrating the means by which biodiversity can be maintained. We examined the effects of removing *Lantana* by uprooting in Marwahi forest of Chhattisgarh and, measured the response of microbial activity, soil carbon, and soil seed bank to evaluate the impacts of *Lantana* on soil health. Two sites (*Lantana* treated and untreated) were monitored and we measured soil microbial population, enzyme activities, soil organic C (at three depths: 0–15, 15–30 and 30-45 cm) and soil seed bank (at two depths: 0-5 and 5-10 cm) using five 10 × 10 m quadrats per site. The activity of microbial decomposers groups as measured by fluorescein diacetate assay was 61-64% higher in the untreated soil compared to treated soil. Similarly, the microbial respiration was reduced by 66-70% in treated compared to untreated soils. However, unlike the enzymatic activities, soil organic C was higher in *Lantana* treated soil compared to untreated soils. The population of total fungi and phosphate solubilizing microorganisms was also low in treated plots. The number of weed seed germination was lower in soils (0-5 cm) taken from *Lantana* invaded sites compared with uninvaded sites, an indication that *Lantana* invasion has the potential to deplete the soil seed bank of other species. The re-appearance of *Lantana* was higher in untreated area, and lower in treated area, signifying the effectiveness of management practice employed. Similarly, the density and diversity of vegetation was higher in treated area. The changes observed in the soil microbial activities and seed bank data shows that *Lantana* has a role to play in shaping these measures, however, a more likely explanation is that longer term monitoring is required before the full impact of *Lantana* removal can be detected. No *Lantana* removal is likely to be effective without post-removal monitoring, hence, it is highly warranted to undertake a holistic study to understand the ecological impact of *Lantana* removal in the state of Chhattisgarh. Further investigation is required into how *Lantana* removal affects soil nutrient levels and biodiversity in the medium to long term.

Trend analysis of production and consumption of key herbicides in India

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Weeds remained a serious threat to agriculture. One of the studies from ICAR-Directorate of Weed Research, Jabalpur revealed that weeds cause an estimated $11 billion crop yield loss every year in India. India has traditionally relied heavily on hand weeding for weed management. However, cost-saving measures like herbicides usage became more popular as agricultural labour became more expensive and scarcer. Against this backdrop, the present study sought to determine the production and consumption growth trend of important herbicides in India. Secondary data published by the Directorate of Plant Protection, Quarantine & Storage, Ministry of Agriculture and Farmers' Welfare, Government of India, was used for the study. The compound annual growth rates (CAGR) of production and consumption of herbicides were estimated by exponential function as it has the advantage of taking all the data points into consideration. The total production of herbicides depicted a compound annual growth rate of 4.72% during 2015-16 to 2019-20 and it was the highest among different groups of pesticides. In terms of the production volume of herbicides, an increasing trend was observed during this period. It was 33 thousand MT in 2015-16 and reached to 39 thousand MT in 2019-20. The highest production (42 thousand MT) was observed in both 2017-18 and 2018-19. While the overall production of pesticides depicted a meager 0.56% growth rate during this period. All herbicides except glyphosate showed a positive growth rate of production during this period. Metribuzin registered the highest growth rate (30.68%) followed by diuron (28.14%) and pretilachlor (12.11%). Total pesticide consumption in India has decreased from 30,678 MT to 24, 694 MT during the five years period from 2016-17 to 2020-21. The estimated compound annual growth rate of total pesticide consumption showed a negative trend (-1.8%) during this period. Among different groups of pesticides, only fungicides showed a positive growth rate of 1.3%. Biopesticide consumption depicted the highest negative growth rate (-7.9%) and herbicides also recorded a negative growth rate (-3.2%). Herbicide consumption dipped from 4,495 MT in 2016-17 to 3325 MT in 2020-21. Among the five key herbicides, pretilachlor depicted the highest compound annual growth rate (32.1%) followed by 2,4-D (5.8%) and atrazine (4.2%). Other two herbicides, *viz*. butachlor and glyphosate showed a negative growth rate trend. Butachlor was at the highest position in terms of consumption volume (812 MT) in 2016-17 and it dipped to the lowest position (209 MT) in 2020-21 with a negative annual growth rate (-23.5%). Whereas, the volume of pretilachlor consumption increased from 359 MT in 2016-17 to 666 MT in 2020-21. Understanding the trends in the production and consumption of different herbicides is very crucial as it can be used to predict supply-demand gaps.

Weed management aspects of the United States turfgrass Industry: Current scenario and future outlook

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The United States turfgrass industry represents the world's largest turf segment, comprising golf courses, residential turf, park, and athletic fields with over 20 million hectares and revenue of over $ 62 billion (USD). Tall fescue (*Festuca arundinacea*) is the most common lawn grass, but several other species are also utilized, including Kentucky bluegrass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), fine fescue (*Festuca ovina*), bermudagrass (*Cynodon* spp.), and zoysiagrass (*Zoysia japonica*). Most common weeds of turfgrass in the United States include crabgrass (*Digitaria* spp.), dandelion (*Taraxacum officinale*), annual bluegrass (*Poa annua*), white clover (*Trifolium repens*), and nutsedge (*Cyperus* spp.). Herbicides are used as the primary tool for weed control in managed turfgrass. With the highly intensive use of herbicides, the risk of troublesome weed species, including annual bluegrass, crabgrass, and goosegrass, evolving resistance to commonly used herbicides and sites of action (SOAs) also escalated. Application timing of herbicides is vital to maximize weed control. Preemergence herbicides must be applied before weeds emerge and postemergence herbicides are applied to existing weeds. Since most weeds are mature perennials, herbicide rates are often higher than those used in production crops. The most common herbicides used to control weeds in Virginia include quinclorac, fenoxaprop, and mesotrione for post-emergence control of grass weeds; 2,4-D, dicamba, MCPP, triclopyr, fluroxypyr, and metsulfuron for post-emergence control of broad-leaf weeds; and pendimethalin, prodiamine, dithiopyr, oxadiazon, oryzalin, and bensulide for pre-emergence control of grass and broad-leaf weeds. Halosulfuron, trifloxysulfuron, sulfosulfuron, sulfentrazone, and bentazon are utilized for managing sedges. Other important herbicides are penoxsulam, indaziflam, thiencarbazone, topramezone, and methiozolin. Of the 513 unique cases of herbicide-resistant weeds reported globally, 22 were found in managed turfgrass systems such as golf courses, sports fields, and sod production. Some reported species include annual bluegrass, lawn burnweed (*Soliva sessilis*), goosegrass (*Eleusine indica*), annual sedge (*Cyperus compressus*), large crabgrass (*Digitaria sanguinalis*), smooth crabgrass (*Digitaria ischaemum*), spotted spurge (*Chamaesyce maculata*), and buckhorn plantain (*Plantago lanceolata*). Target-site resistance is more commonly reported among turfgrass weeds; however, annual bluegrass biotypes also evolved resistance through non-target-site-resistance mechanisms. With rising cost of herbicide discovery programs, efforts should be taken to prevent weed resistance development that would undermine performance of currently available herbicides. Diversified best management practices are required, including cultural control, competitive turfgrass cultivars, and rotating available herbicides with different SOAs.

Mapping and habitat affinity of greater club rush in wetland rice fields of *Vellayani lake* watershed

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Greater club rush (*Scirpus grossus* L.), locally known as "*kora"* is a very large emergent hydrophyte infesting vast tracts of wetland rice fields in Kerala state. It is a native of South East Asia and is found naturalized in several parts of the world including India. It belongs to the family Cyperaceae, sub family - Cyperoideae often called the "tuberous bulrushes". Once infested, the aggressive weed spreads fast in undisturbed fallow fields and the cost involved in removing it and recovering the field for rice cultivation was prohibitively high, leading to wastage of large area of productive wetland rice fields. Mapping and recurrent checking of invasive plant distributions are central to natural resource management and habitat preservation especially with the varied advantages of Geographical Information System (GIS). The extent of invasion of greater club rush in the wetland ecosystem of *Vellayani lake* watershed was assessed and mapped using Global Positioning System (GPS) and Geographical Information System (GIS) during August 2016 at the active growth stage of the weed. The presence of the weed was located with the help of GPS receiver – eTrex 20X of GARMIN and the weed map was developed using Arc GIS software 9.3. The geographical unit for conducting the investigation belongs to the *Vellayani lake* watershed ($08^0$23'45" to $08^0$28'30"N latitude and $76^0$57'30" to $77^0$2'30"E longitude) in Thiruvananthapuram district, Kerala. Plant and soil samples from the selected region were collected, analysed and the data were correlated with the density and biomass of greater club rush collected from the same spots to assess the habitat affinity of the weed. Weed mapping indicated that greater club rush invasion was concentrated in the north - western side of the wetlands and the water-logged rice fields in this locality were remaining uncultivated and undisturbed for the past 10 to 12 years and the invasion had already spread in an area of about 65 ha in the *Vellayani lake* watershed area which accounted for 47.7 per cent of the existing rice fallows in the flood plains. However, greater club rush invasion was not notice in the wetland pockets which were continuously under rice cultivation. Habitat analysis studies showed that greater club rush was flourishing under a wide range of field conditions which indicated that the weed has high level of habitat tolerance and ecological flexibility. This was probably another reason why the weed has already invaded a vast tract of the wetland rice ecosystem; and if the weed was left unrestrained, more and more areas may get invaded by the aggressive alien weed.

Weed management under conservation agriculture in vegetable based cropping system

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Conventional tillage practices usually decrease soil organic carbon (SOC) (Lal *et al.* 2004) while conservation tillage improves SOC concentration, water storage and reduce erosion and thereby enhancing soil quality and resilience. In Indo-gangetic plains of Uttar Pradesh Rice-wheat cropping system is very intensive and more exhaustive. Conservation Agriculture (CA) technique provides equal or more productivity, improve soil health and higher farm profitability in sustainable way in comparison to conventional practice (Jat *et al.* 2009). Vegetables are the best resource for overcoming micronutrient deficiencies and provide smallholder farmers with much higher income and employment per hectare than other cereal based cropping system. The present experiment was planned with vegetable based cropping system under conservation agriculture for diversified cropping system and to maintain soil health status with objectives to study the effect of tillage practices on soil health and system productivity, to quantify SOC in vegetable production systems and to work out the economics and energetic of vegetable production system. Experiment was laid out during 2019-20, to study the effect of conservation tillage on the production potential and soil heath in vegetable Maize-pea-okra cropping systems. The experiment was laid out in Spilt-split plot design with three main plot treatment Tillage (zero tillage, minimum tillage and rotary tillage), two sub plot treatment (residue, without residue), sub-sub plot treatment four weed management practices (according to crops). The minimum tillage consisted of one cross ploughing with harrow/ cultivator while rotational tillage consists of two cross ploughing with cultivator one harrowing followed by ploughing with rotavator. The recommended dose of fertilizer for the crop was applied at the time of field preparation in conventional (CT) and reduced tillage (RT) treatment while in zero tillage (ZT), fertilizer was dibbled in soil at the time of sowing. In ZT, the residues were retained on surface by cutting the residues of crops and spreading it on soilsurface. While in reduced tillage and conventional tillage the residues of the crop were incorporated in the soil of respective plot by ploughing immediately after the completion of the crop. Pre-emergence herbicides were applied at the time of sowing and post- emergence herbicides were applied 25 day after sowing. Zero tillage with residue retention produced maximum green cob yield (14.6 t/ ha) which was significantly superior over other tillage treatments. Among weed management practices maximum yield was obtained with 2 handweeding (15.5 t/ha) which was at par with the application of topramezone 25 g/ha and tembotrione 15.2 t/ha. Residue retention/incorporation, in general improved the yield in all the crops which may be due its positive influence on weed suppression as well as moisture conservation and increase in organic carbon in the soil. The increase in organic carbon (%) of soil due to residue incorporation/retention was 6.06% over residue removal. The increased organic carbon content of soil in plots where residues of crops were incorporated /retained over its removal The organic carbon content of soil was in general more in residue retention/incorporation over residue removal in all the three tillage treatments.

Effect of integrated weed management practices on weed dynamics and productivity of long duration pigeonpea (*Cajanus Cajan*)

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Field experiment was conducted at research farm of Tirhut College of Agriculture, Dholi ($25^0$982 N $85^0$762 E and an altitude of 51.3 m above mean sea-level) a campus of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during three consecutive years from 2019-20 to 2021-22. The soil of the experimental plot was sandy loam in texture low in organic carbon (0.34%), available nitrogen (156.4 kg/ha), phosphorus (12.66 kg/ha) and potassium (154.2 kg/ha) with pH 8.1. The treatment comprised of: weed free by hand weeding twice at 20, 40 and 60 days after seeding (DAS), weedy check, hand weeding twice at 20 and 40 DAS, pre-emergence application (PE) of pendimethalin 0.75 kg/ha + post-emergence application (PoE) of imazethapyr 100 g/ha at 20 DAS followed by (*fb*) interculture operation at 50 DAS, pendimethalin 0.75 kg/ha PE *fb* chlorimuron ethyl 9 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS, pendimethalin 0.75 kg/ha PE *fb* fenoxaprop-ethyl 70 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS, pendimethalin 0.75 kg/ha PE *fb* + propaquizalop 50 g/ha + imazathapyr 75 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS. Pendimethalin 0.75 kg/ha PE *fb* mixture of sodium acifluorfen + clodinafop propagyl 245 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS, pendimethalin 0.75 kg/ha PE + *fb* chlorimuron-ethyl 9 g + quizalofop ethyl 50 g PoE 20 DAS *fb* interculture operation at 50 DAS, pendimethalin 0.75 kg/ha + chlorimuron-ethyl 6 g+ quizalofop-ethyl 37.5 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS, pendimethalin 0.75 kg/ha PE *fb* chlorimuron ethyl 9 g/ha + fenoxaprop ethyl 70 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS, pendimethalin 0.75 kg/ha PE *fb* chlorimuron ethyl 6 g + fenoxaprop-ethyl 50 g/ha PoE 20 DAS *fb* interculture operation at 50 DAS and pendimethalin 0.75 kg/ha PE *fb* mixture of imazathapyr + imazamox 100 g/ha PoE 20 DAS followed by interculture operation at 50 DAS. The experiment was laid out in randomized block design and replicated thrice. Pigeonpea variety 'Bahar' was sown in rows 60 cm apart in third week of July and was harvested in third week of April in each year. The plant-to-plant distance of 20 cm was maintained by thinning third week after sowing. The crop was fertilized with 20:40:20:20 kg NPKS/ha. Full dose of NPKS was applied at the time of sowing. Weed count and weed dry-biomass were recorded 75 DAS. Weed control treatments significantly reduced weed density and weed dry-biomass and produced significantly higher grain yield than weedy check. Among the weed management practices, integration of pre-emergence application of pendimethalin 0.75 kg/ha followed by post-emergence application of chlorimuron ethyl 9 g/ha + fenoxaprop-ethyl 70 g/ha (20 DAS) followed by interculture operation at 50 DAS recorded lowest weed density, weed dry-biomass and highest weed control efficiency and produced similar grain yield as weed free and hand weeding twice at 20 and 40 DAS. Likewise, pre-emergence application of pendimethalin 0.75 kg/ha followed by post-emergence application of chlorimuron-ethyl 9.0 g/ha + quizalofop -ethyl 50 g/ha (20 DAS) together with inteculture operation at 50 DAS also produced similar grain yield similar to weed free and hand weeding twice. These treatments also recorded higher net return and B: C ratio than weed free plot and hand weeding twice.

Microencapsulation of pyrazosulfuron-ethyl and diclosulam in polymeric systems for prolonged and improved weed control efficiency

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Sulfonylureas, a modern family of herbicides, are widely applied for the selective weed control in various field-crops. Sulfonylurea herbicides have high herbicidal activity at low application rates of 10-1000 times less than of traditional formulations. Sulfonylureas exhibit extremely low acute and chronic mammalian toxicities, which increase the use of herbicides for controlling weeds extensively in rice production. However, sulfonylurea herbicides are short-lived in soil due to microbial degradation and chemical hydrolysis. Thus, affecting its herbicidal activity. Sulfonylurea herbicides are weak acid derivative, which are readily soluble in water and leach down to the deeper aquifers. The use of Controlled Release Formulation of herbicides will regulate the release and availability of active ingredients (herbicides) in soil, which in turn improves the weed control efficiency. With this background, the research was designed for the encapsulation of pyrazosulfuron-ethyl herbicide in pectin polymeric system through ion gelation for the controlled release of herbicide to achieve prolonged weed control in transplanted rice and minimize leaching of herbicides into the soil. Encapsulated pyrazosulfuron-ethyl applied 10, 20 and 30 gha^{-1} was resulted in yield increase of 1.82, 5.47 and 27.13 per cent over commercial formulation 30 g/ha. Encapsulated pyrazosulfuron-ethyl 10 g/ha had lower weed control efficiency, weed control index and herbicide efficiency index compared to the application of commercial formulation 30 g/ha. Diclosulam is an effective pre-emergence herbicide controlling wide spectrum of weeds in groundnut. However, the application of diclosulam cause phytotoxicity in early stages of groundnut. Diclosulam is mobile in nature, which results in leaching of herbicide into groundwater. Hence, research project was proposed to encapsulate diclosulam in xanthan gum based polymeric system for facilitating the controlled release of herbicide molecules. The encapsulation of diclosulam prevent the burst release of herbicide, thus maintaining the concentration of herbicide in soil not to cause phytotoxicity in groundnut crop and prevents the leaching of herbicide. Microencapsulation of diclosulam was carried out with xanthan gum and sodium alginate polymeric system through ion gelation method. The dripping of polymer solution in the counter ion solution results in the formation of polymeric beads spontaneously. The introduction of active ingredient in polymeric solution form beads in the counter ion solution enclosing active gradient while forming the beads. The lower weed abundance and relative density of weeds were observed in the encapsulated diclosulam applied pots. Higher weed control index and weed control efficiency was found with application of diclosulam 35 g/ha, while application of commercial formulation of diclosulam 25 g/ha controlled weeds efficiently, however, application of commercial diclosulam caused phytotoxicity. Application of encapsulated herbicides 20 and 25 g/ha were also equally effective on the control weeds where the minimum number of weeds were recorded until the critical weed free period of 45 days in groundnut coinciding critical period of crop weed competition of groundnut. There is a scope to reduce the volume of herbicides with encapsulation for controlling weeds besides ensuring prolonged weed control.

Poster presentations

TECHNICAL SESSION 1

New ways to deal with weeds, *i.e.* new technologies

Poster 1

Weed interference, wheat productivity, and soil properties under a conservation agriculture-based pigeon pea-wheat system

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Recently, conventional agriculture in the Indo-Gangetic plains (IGP) has encountered several problems like declining/stagnant crop yield, farm income, and factor productivity; deteriorating soil health; increased surface run-off and erosion; global warming; increased biotic interferences and declining biodiversity; secondary salinization and sodicity; susceptibility to climatic variability; and air and ground water pollution. Conservation agriculture (CA) with three principles (minimal soil disturbance; permanent soil cover with crop residue or cover crops, and crop rotations) provides a more sustainable system that can reverse resource degradation processes and make efficient use of natural resources through integrated management of available soil, water, and biological resources combined with external inputs. Adopting CA based system through substitution of rainy season (~*Kharif*) rice with pigeon pea provides numerous benefits, including C sequestration, soil nutrient improvement, increased nutrient-use efficiency, climate change adaptation and mitigation, increased water productivity, and crop productivity and profitability. Therefore, the effects of a long-term (~12 years) conservation agriculture-based pigeon pea-wheat system (PWCS) on weed interference, wheat yield, and soil properties during winter (~*Rabi*) 2021-22 were studied at the ICAR-Indian Agricultural Research Institute, New Delhi, India. The climate is semi-arid and subtropical, and annual rainfall is about 710 mm. The experiment was carried out in the 12th year of the long-term CA experiment that was initiated in 2010. Ten treatments included conventional tillage (CT); zero-tillage (ZT) with crop sown on permanent raised bed (PNB), permanent broad bed (PBB), and permanent flatbed (ZTFB) with and without crop residue retention. These PNB, PBB, ZTFB with pigeon pea residue (R) treatments were further supplemented with 75% and 100% of the recommended dose of N (*i.e.*, PNBR75N, PNBR100N, PBBR75N, PBBR100N, ZTFBR75N; ZTFBR100N). Results showed that grassy weed density differed significantly at 30 days after sowing (DAS) due to different tillage, residue, and nitrogen management practices and was significantly higher in PNB followed by PBB, whereas the densities of broad-leaved and sedge weeds were significantly higher in CT. As a result, total weed density was found to be significantly higher in CT, and significantly lower in permanent flat bed with residue retention and 75% or 100% N application (*i.e.* ZTFBR75N or ZTFBR100N). Wheat productivity was also significantly influenced by varying tillage, residue, land configuration, and N management practices. CA practices led to higher wheat grain yield by 8.1-14.9%, straw yield by 2.8-8.1%, and biological yield by 4.9-10.8% compared to CT. The yield at 75% and 100%N, however, was comparable. The residue retention treatments resulted in improved soil properties, and resource saving than without residue and CT treatments. Hence, CA-based pigeon pea-wheat system at 75 or 100% N application could be a sustainable practice leading to better weed suppression, higher crop productivity, and improved soil health and should be adopted in the IGP of India.

Poster 2

Phytotoxic activity of essential oils and aqueous extract of medicinal and aromatic plants on *Phalaris minor*

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Medicinal and aromatic plants have the potential to transmit volatile allelochemicals and influence the species in their environment. In this regard, phytotoxic activity of essential oil emulsions (EOEs) of three aromatic plants such as *Mentha piperita, Chrysopogon zizanioides*, *Mentha arvensis* and aqueous extract of medicinal plant *Andographis paniculta* were evaluated on *Phalaris minor* along with *Triticum aestivum* as test crop in pot culture studies during 2020-2021 at experimental farm CSIR-CIMAP, Lucknow.Weed seeds (*P. minor*) were purchased from ICAR-Directorate of weed research (DWR), Jabalpur and crop seeds, *Triticum aestivum* (Variety-HD 2967) were purchased from local market. EOEs concentration C1-0.1, C2-0.5, C3-1.0% as a pre-emergence (PE) and concentration C1-2.0, C2-4.0, C3-8.0% as an early post-emergence (EPoE). *A. paniculata* leaf powder at a rate 5, 10, 15g^{-1} pot were applied as a mulch in pre-emergence treatment and aqueous extract concentration C1-3.0, C2-5.0, C3-10.0% as an early post-emergence treatment. The measured features to check the phytotoxicity of EOEs and aqueous extracts were growth and plant physiological parameters of *P. minor* and *T. aestivum*. Chemical composition of essential oils and aqueous extract were analyzed by GC/GC-MS and HPLC respectively. Results of pot experiment revealed that germination percentage (%), seedling vigor index I (SVI) and vigor index II (SVII) of *P. minor* was more affected compared to test crop *T. aestivum* by essential oil emulsion and aqueous extract treatments. Maximum reduction for SV I and VI II in *P. minor* were recorded in T2C3 (76.47%), T3C3 (91.48%) treatments where as in *T. aestivum* highest reduction for VI I and VI II were observed in T1C3 (46.32%), T3C3 (47.94%) respectively. Different EOEs and aqueous extracts with varying concentration had significant effects (p=0.05) on chlorophyll content, REL and proline accumulation, which is a good selective effect for the development of bioherbicides in the future. A significant decrement for plant growth and physiological parameters were recorded in *P. minor* compared to *T. aestivum*. In *P. minor* physiological process such as relative electrolyte leakage was recorded the highest in T3C3 (47.16%) followed by T2C3 (38.86%), T1C3 (22.80%) T4C3 (12.70%) as compared to untreated control (10.13%). At higher concentration of each treatment grain yield per plant decreased in the range of 7-29% with respect to control. The data on phytotoxicity rating showed that injury symptoms in *T. aestivum* plants were less affected as compared to *P. minor* weeds. Our study revealed that for the *P. minor* control, medicinal and aromatic plant based allelochemicals can be used as a bioherbicides.

Poster 3

CRISPR/Cas9-mediated genome editing: An important tool for development of herbicide resistant crops

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Weeds have continually interrupted the crop production leading to a heavy yield loss, since domestication of crop plants. Weeds in farmland competite with crops for water, nutrients, space and sunlight. They also act as an alternate and co-lateral host for diseases and insects thereby adversely affecting crop growth, productivity and the quality of produce. Additionally, several weeds pollen toxins could be a health hazards to humans and animals. Thus, weed control is very crucial to ensure the availability of sufficient food for rapidly increasing human population. Currently, herbicides have been widely used in croplands as the primary method to control weeds due to their effectiveness and economic viability. However, extensive and recurrent use of the same herbicides also develops herbicide resistant weeds rendering herbicide useless. Thus, the development of herbicide resistance crop varieties along with the improved agronomic traits are needed for enhancing crop production by enabling farmers to manage weeds in a sustainable manner. Various conventional and modern breeding approaches have been successfully used in the past that played a key role in developing herbicide-resistant crops (HRC's) through transgenic techniques. However, probable risk of transfer of foreign genes and other regulatory concerns constrained the promotion and global acceptance of herbicide-tolerant crops (HTC's) in some regions of the world. Therefore, a more precise and benign breeding technique is highly required. Genome editing techniques have been effectively used in various crop species to target genes for improving the crop productivity and tolerance against insect-pests including conferring herbicide resistance. Among all genome editing techniques, mediated system is widely deployed and most effective one to accelerate breeding for desired traits including herbicide resistance. This technology leads to precise modifications of DNA sequences that can confer herbicide resistance without the integration of exogenous DNA, therefore such plants are non-GM and transgene-free; similar and non-distinguishable to those developed via conventional or transgenic crop breeding. Thus, the CRISPR-Cas9 based herbicide resistant plants could have more public acceptance than GM crops. CRISPR-Cas9 mediated genome editing has made it possible to introduce multiple-gene modifications, simultaneously to induce multiple-trait improvements in a plant. Therefore, multiple-herbicide resistance would be another promising approach to efficiently cope with increasing herbicide resistant weed problems. CRISPR-Cas9, have brought innovation in genome editing technology that opens new vistas to provide sustainable farming in modern agricultural industry especially for herbicide resistance.

Nanotechnology in weed science

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Weeds compete with crops for light, water, and nutrients. Herbicides are widely used as a weed management tool in agriculture. However, overexploitation and indiscriminate use of herbicides in order to increase crop yield have caused hazardous impact on environment including water body's contamination, toxicity in nontarget organisms as well as detrimental effects on human health. World wide losses caused by pests were estimated as 30% of food production. Of this, weed contribute about 13% loss, besides the ill effects of synthetic herbicides on human and the environmental health. The research on the use of nanotools in weed management is being conducted to develop technologies for future weed management, by minimizing the costs and the environmental effects of the use of chemical herbicides. Nanoherbicides provide an opportunity for farmers to control annual, perennial, and parasitic weeds by blending with the soil or sprayed on weed plants without the use of excessive amounts chemicals and without toxic residues and environmental problems. Nanoformulations are being used in weed control, especially polymer formulation (control release or nanocapsulation) or nano-emulsions for natural product extracts, essential oils, and active ingredient (AI) of synthetic herbicides. Encapsulation of herbicides in nanomaterials minimizes the loss of herbicide along with its sustained release and increased specificity toward target weed. Several polymeric nanoparticles, nanocapsules, and nanospheres are used as carriers for herbicides. Polymers such as alginate, chitosan, pectin, poly (epsilon-caprolactone), poly (methylmethacrylate), and poly (lactic-*co*-glycolic acid) are considered as ideal nanocarriers for several herbicides such as paraquat, 2,4-D, diuron, ametryn, atrazine, and simazine, whereas other nanocarriers such as rice husk nanosorbents, mesoporous silica nanoparticles, and nanoclay can be applied for fabrication of nanoherbicides. Nanoherbicides are effective against a variety of weed species such as *Echinochloa crus-galli*, *Chenopodium album*, *Bidens pilosa*, *Amaranthus viridis*, and *Raphanus raphanistrum*. Biological synthesis is an efficient method for nanoparticles and has been used in various applications. Many researchers are focusing on using weeds to find an environment-friendly technique for producing well-characterized nanoparticles. Hence, nanoherbicides can become an efficient strategy in overcoming drawbacks of excessive use of conventional herbicide formulations in agriculture.

Poster 5

Weed management in intensive cropping systems - A review

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Weeds have been recognized as a problem since then and the battle against weeds is a never ending one and often the costliest agronomic input for successful crop production. Between humans and continuing food supply, there stand four natural hazards, *e.g.* weather, weeds, insect-pests and plant diseases. Weeds are the major deterrent to the development of sustainable crop production. Wweeds dictate most of the crop production practices and cause enormous losses (37 per cent) due to their interference. Farmers follow several practices for managing weeds in different crops/cropping systems, of which at present the use of herbicides is on the top due to the scarcity of labourers. The sustainability of different systems is being questioned because of environmental, social, and economic concerns caused by global competition, production cost, soil erosion, environmental pollution, and concern over the quality of rural life. Dramatic and widespread herbicide resistance in weed populations is just another example of evolution in weed populations exposed to a control tactic or a cropping system selection pressure. Current and future cropping practices will more frequently lie within the conservation production approach, based on reduced tillage and crop residue retention. The increasing need to improve soil structure, retain nutrients, and conserve soil moisture will continue to drive the widespread adoption of conservation cropping practices. Even though conservation cropping has led to herbicide reliance and subsequently herbicide resistance, this approach has provided substantial gains in productivity and reverting to less conservative systems for the shake of weed control is no longer an option. However, practices such as stubble burning and tillage can continue to be used for weed control in conservation cropping systems but their use now must be strategic, and not a routine as previously practised. Apart from, Conservation agriculture (CA) has a major influence on the relative abundance of weed species, while weed control is perceived as one of the most challenging issues with the initial adoption of CA. However, adoption of CA, influences the weed population differently over conventional agriculture as tillage manipulates the weed habitat. Thus, weed management in CA possesses a great challenge for farmers. This is mainly due to minimum soil disturbance resulting in most of the weed seeds remain over the top layer of soil and crop diversification brings change in weed composition. In intensive agricultural systems, the rotation of tillage systems, and the use of crop residue as mulch, weed competitive cultivars with high yield potential, appropriate agronomic practices and appropriate herbicide timing, rotation, and combinations, need to be integrated to achieve effective, sustainable, and long-term weed control. Introduction of transgenic crops resistant to non-selective herbicide like glyphosate provides farmers the flexibility to control a broad-spectrum of weeds with minimal crop damage.

Mycoherbicides: An ecological and sustainable approach to weed management

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An increasing concern and awareness about environmental, health hazards and residual toxicity due to pesticides has led to the shifting towards more ecological and sustainable ways to control the pests and diseases. Several fungi are pathogenic to specific species of weeds and such fungi are used to kill or eliminate the weeds. Mycoherbicides are plant pathogenic fungi which are used to control the weeds. The mycoherbicides can be integrated with the other agricultural practices. The use of mycoherbicides also ensures the host specificity and thus establishment of a host range. It is an advantage because pathogen can be safely used to eliminate weeds from closely related crop species without the fear of crop damage as most chemical herbicides are not as selective. The development of mycoherbicides is more of focused on the species that escape the chemical weed control program. Mycoherbicides can multiply on the target weeds and spread rapidly, they persist in the weed plants for a long time in the form of spores till new weeds emerge but some mycoherbicides gets destroyed after killing the weeds. The mycoherbicides are developed through genetic engineering, tissue culture or protoplast fusion which is used to combine the pathogenicity of different plant pathogenic fungi. The mycoherbicides also persists within the infected seed, soil and plant matter which provides enough inoculum for natural control without application each year. Commonly used mycoherbicides are COLLEGO, DeVine, LUBOA2 and BioMal. COLLEGO is the trade name of spores of *Colletotrichum gloeesporiodes f.sp. aeschynomene* which is used to control *Aeschynomene virginica* weed and DeVine is the spore's suspension of *Phytophthora palmivora* which is commonly used to control the milk weed (*Morrenia odorata)* in citrus. Considering the small initial investment, effectiveness, host specificity, persistence and eco-friendly, mycoherbicides are considered as an ecological and sustainable method of pest control.

Weed preservation technique

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A study was conducted on weed preservation technique at N.M. College of Agriculture, Navsari Agricultural University, Navsari during 2016-2020. Since man first started domesticating and cultivating plants and animals around 10,000 B.C., weeds are one of the most prominent hazards, have been recognized as a concern. The fight against weeds is ongoing, and it frequently requires the most expensive agronomic inputs for the success of crop production. In India, weeds account for over 45% of the entire yearly loss of agricultural produce due to pests, followed by insects with 30%, diseases with 20%, and other pests with 5%. Despite this, the dangers of weeds' direct and indirect effects go unnoticed until the crop is harvested so, identification of weeds are very important. This investigation is on liquid preservation of different weed species, *viz. Amaranthus viridis* L., *Amaranthus spinosus* L., *Avena fatua* L.,*Celosia argentea* L., *Chenopodium album* L. *Convolvulus arvensis* L., *Cynodon dactylon* L., *Cyperus rotundus* L. *Eclipta alba* L., *Echinochloa colona* L. *Digera arvensis* L., *Euphorbia hirta* L., *Sorghum halepense* L. *Tridax procumbens* L., *Lantana camera* L., *Solanum xanthocarpus* L., *Xanthium strumarium* L., *Melilotus alba* L., *Portulaca oleracea* L., *Alternanthera sessilis* L., *Datura stramonium* L., *Parthenium hysteroporus* L., *Cuscuta reflexa* L., *Orobanche cernua* L., *Phyllanthus niruri* L., *Eichhornia crassipes* Solms, *Vernonia cinera* L., *Zizyphus rotundifolia* L. The experiment comprised different concentration of chemicals and distilled water. Such as formaldehyde (37%) 100% ; formaldehyde (37%) 50% + distilled water 50% ; formaldehyde (37%) 75% + distilled water 25% ; formaldehyde solution (37%) 75 ml + distilled water 1000 ml+ + copper nitrate 2 gm + copper sulphate 2 gm + acetic acid 100% solution (add drop by drop and stir up to solution like light blue colour). The total volume of the liquid preparation made one litre. Glass container was used for this preservation. It can be concluded that formaldehyde solution (37%) 75 ml + distilled water 1000 ml +copper nitrate 2 g + copper sulphate 2 g + acetic acid 100% solution (add drop by drop acetic acid and stir up to solution like light blue colour) effectively preserved most of the weed species with original green colour for longer duration, but they lost their flower colour after some time. However, monocot weed species were better preserved than dicot weed speices, it depends on nature of weed species.

Deciphering plant growth promotion potential of native atrazine degrading bacteria

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Atrazine is the most widely used triazine class herbicides for management of weed in maize, sugarcane and sorghum. Its residues can remain in soil up to 4 year and can migrate to ground water. It can affect the properties of soil as well as alters its pH and cause an imbalance of soil fertility which directly affects crop yield. The aim of the study was to isolate and characterize the native atrazine degrading bacteria from soil and to decipher their plant growth promotion activity and atrazine degradation potential. Total 21 bacterial isolates were obtained following enrichment isolation technique and screened for atrazine degradation efficiency. Out of which 9 were found effective and among them, 2 best isolates were selected based on their ability to utilize atrazine at higher concentration (1000 ppm) as sole source of carbon and energy. Based on results of the polyphasic characters, *viz.* morphological, cultural and molecular, isolate A2 identified and designated as *Paenarthrobacter ureafaciens* AAUATR 2 (NCBI Accn No: MZ636701) and isolate AN4 as *Pseudomonas taiwanensis* AAU ATR 4 (NCBI Accn No: MZ636704). Atrazine degradation potential study through spectrophotometric and chromatographic/LC-MS analysis revealed that, 98.98% degradation was achieved by consortium *P. ureafaciens* AAUATR 2 and *P. taiwanensis* AAUATR 4 at 20 days after inoculation. These isolates were also screened for presence of different plant growth promoting attributes and found to possess multiple PGP traits, *viz.* P, K, Zn solubilization; indole acetic acid production; ACC deaminase enzyme production and antifungal activity against phytopathogenic fungi. The highest P solubilization in terms of solubilization index on solid agar plate and release of soluble P in liquid media was recorded for *P. taiwanensis* AAUATR 4, this isolate also showed higher IAA production as well as zinc solubilization and biocontrol activity against the phyto-pathogenic fungi *Fusarium oxisporum* and *Curvularia lunata*. Moreover, the isolates were found to enhance maize plant growth in terms of root length, shoot length, root fresh weight, shoot fresh weight, root dry weight and shoot dry weight in presence of applied atrazine in soil with degradation efficiency of 99.97% at 30 days after sowing. The native bacterial isolates can be further utilized for remediation of atrazine contaminants soil with enhancement in plant growth and yield for sustainable agro-ecosystem.

Using nanoparticles to improve the absorption and translocation of glyphosate in purple nutsedge tubers

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Cyperus rotundus L. (purple nutsedge) is one of the world's worst weeds based on its occurrence in 52 crops in 92 countries and its capacity to cause substantial yield losses. It reproduces extensively by rhizomes and tubers. The tubers contain inert buds and function like the seeds of annuals, acting as the primary dispersal units. The sprouting buds form one to two upwardly growing rhizomes that produce the basal bulb under the influence of light. The lateral rhizomes will give rise to the formation of secondary sprouts that will form tertiary sprouts, and so on. The abundantly produced tubers present an efficient means of dispersal and reproduction. Even if the aerial parts of the weeds die, the underground parts may continue to live and put forth fresh shoots. Hence, complete control of these weeds is not achieved and temporary control can be possible by the application of herbicides. The *C. rotundus* leaves have waxy surface and the epicuticular wax amount and its composition on old leaves would likely have a greater effect on herbicide than young leaves. The addition of more surfactants to the spray solutions improves the herbicide activity. But the success of this weed control is mainly depends on the behaviour of sprouting, formation of rhizome, bulb, tuber and nature of herbicides, uptake pattern and ability of weeds. This study was conducted to improve the translocation ability of glyphosate in *C. rotundus* tubers with the help of nanoparticles. Pot culture study was conducted at the Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during 2020-21. Nanoparticles of iron oxide, silver, titanium dioxide and zinc oxide nanoparticles were synthesized in the lab and characterized for their size, shape, functionality, elemental composition etc. The synthesized nanoparticles were utilized to improve the absorption and translocation of glyphosate to the tubers by degrading the phenols and starch content in the tubers to reduce tuber multiplication rate of *C. rotundus.* The combined application of silver nanoparticles at 1.0% + glyphosate at 1000 ppm resulted in excellent control, greater physiological changes in weeds and increased glyphosate translocation into the tubers. Combined application of glyphosate with silver and titanium dioxide nanoparticles exhibited higher herbicide translocation to the primary tubers and branch tubers and left less viable tubers.

Poster 10

Nanoencapsulation of herbicide: A new window for protected application

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Excessive and inappropriate uses of chemical herbicides have gradually resulted in the occurrence of a wide array of problems ranging from food and environmental contaminations to the appearance of resistant biotypes. Using plant based, natural, and semisynthetic herbicides would be less hazardous for the environment, human health and food web. Therefore, they could be considered as a green, safe and sustainable alternative to synthetic and chemical herbicides. Nanotechnology offers exciting ways for averting the herbicide overuse and also a safe and effectual delivery. The usage of nanostructured systems in agriculture has been increasing in the current era for the controlled release of herbicides. The nanostructured herbicide could substantially reduce the herbicide consumption rate and promise increased crop productivity. This technology of exploiting nanomaterials guarantees to improve the current agricultural practices via the enrichment of management methods. Nanoherbicides are being developed for addressing the issues in annual weed management and also for fatiguing the weed seed collection. The nanostructured formulation performs action through controlled release mechanism. The nano herbicides comprise a wide range of entities such as polymeric and metallic nanoparticles. Nanoherbicides require a glance in order to place nanotechnology at the premier level. Nanotechnology with promising results in the agricultural sector with its unique way of applying the pesticides, fertilizers etc., could enable the human population to finally visualize the dream of attaining sustainable and eco friendly agricultural technology. This dream of exploiting the nanotechnological methods in agriculture is still in nascent stage. Therefore, development of systems that would improve the release profile of herbicides without altering their characteristics and novel carriers with enriched activity without significant environmental damage is the focus areas that require further investigations.

Encapsulated herbicides: A novel approach for efficient and environmentally friendly weed management

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Weeds grow along with the crop plants and interfere with their management practices. The growing menace of weeds in India has led to the increased losses in the yield of crops. The ease in controlling the weed menace has been possible due to the use of herbicidal formulations. The herbicides used to manage weeds often disturb the soil ecosystem due to the ability of the herbicides to retain in soil for a longer period than desirable which is not only potentially harmful to the crops but also lethal for the soil micro-environment. Because of the extensive use of herbicides, the application of controlled release systems is both environmentally and economically desirable.Nano herbicide is a herbicide inside nano particles. Nanoherbicides are formulated by exploiting the nanotechnological potential for effectual delivery of chemical or biological pesticides with the help of nano sized preparations or nanomaterials-based herbicide formulations. Nanoencapsulation size is <0.2 µm. Encapsulating herbicides with nanoparticles is a method that can boost the efficiency of herbicides by aiming at the specific receptor of the specific weed after entering into the root system and inhibiting glycolysis is thus starving them to death. Nanoencapsulation of herbicides is done with the purpose of its slow release, so that the active ingredients are released and available in concentration and with a duration that is just right to get an intended response from the weeds without getting any negative response from the crop plants. Nanoencapsulation is a membrane-controlled system in which the herbicides are coated with any semi-permeable membrane that may be, organic or inorganic polymer, so that they are dissolved by the water and the active ingredients are released as a result of diffusion, osmotic pressure, ion exchange or degradation of matrices.Nano herbicides reduce the requirement of a.i., act as good carriers, protect from premature degradation of a.i., enhance the absorption, increase the bioavailability and provide greater retention time for herbicides, increase the safety and reduce the residues in soil, but they are costly, time consuming, have rigorous registration procedure and less ongoing research worldwide**.** Herbicide encapsulation is a promising evolving technology for safe and effective weed control. They are more stable, effective and less toxic. But still it is in infancy stage and a lot more research is required before encapsulated herbicides become a part of common agricultural use.

Sustainable approach to weed management: The role of precision weed management

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Weeds are as old as agriculture, and from the beginning, farmers recognized that the presence of those unsown plant species interfered with the growth of the crop they intended to produce. In the last few decades, the increase in the world's population has created the need to produce more food. In addition, problems related to climate change, water scarcity or decreasing amounts of arable land have serious implications for farming sustainability. Weeds can affect food production in agricultural systems by decreasing the product quality and productivity due to the competition for natural resources. Herbicide resistance in some weed biotypes is a major concern today and must be tackled. Thus, there is a need for an effective and sustainable weed management process, integrating the various control methods (i.e., cultural, mechanical and chemical) in a harmonious way, without harming the entire agrarian ecosystem. Sustainable weed management comprises a suite of weed management options, including integrated weed management (IWM) which is based on the employment of a multiplicity of weed control strategies. IWM aims to optimize crop production and increase grower profit through the concerted use of preventive strategies, scientific knowledge, management skills, monitoring procedures and the efficient use of control practices. The recent development of weed control technologies can promote higher levels of food production, lower the amount of inputs needed and reduce environmental damage, invariably bringing us closer to more sustainable agricultural systems. In this context, a wide and rapidly expanding range of new technologies have been developed and implemented in agricultural practices, which also play a key role in progress towards economically and environmentally sustainable weed management. Precision weed management leads to a reduction of inputs without decreasing weed control effectiveness. Studies and experiments have shown significant potential savings and technical progress in sensing, weeding and spraying technologies. Some of these technologies have been commercially exploited.

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Nano encapsulated herbicide formulations as a novel method to manage weeds in the rainfed groundnut

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Groundnut (*Arachis hypogaea* L), also known as peanut is rich in protein and edible oil and is highly essential to the financial and nutritional security of farmers and consumers throughout the world. It is an essential crop for the production of food, fuel, and oil. India occupies second position in groundnut production with 6.73 million tonnes per year and supplies 13.58% of world's groundnut production. One of the reasons for the decline in groundnut production is weeds as they are regarded as the most significant problem because of the enormous losses they cause. Although weed management in irrigated groundnut is extensively studied, relatively less attention has been given to rainfed groundnut weed management. Weeds are a major hindrance that prevent higher yields attainment under rainfed situation. There is an exigency to develop a suitable modern strategy for controlling weeds under rainfed situation. Encapsulated herbicides with smart release pattern that releases herbicides only when the moisture becomes available would be more appropriate for rainfed weed management in groundnut. Hence, four pre-emergence herbicides were encapsulated through solvent evaporation method and tested for its efficiency in rainfed groundnut. Field experiments were conducted at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore during *Kharif* 2021 and late *Rabi* 2022. A randomized block design with three replications was used. The treatments consisted of: sulfentrazone 200 g/ha and 250 g/ha with and without encapsulation, oxyfluorfen 200 g/ha and 250 g/ha with and without encapsulation, diclosulam 20 g/ha and 25 g/ha with and without encapsulation, metolachlor 1 kg/ha and 1.25 kg/ha with and without encapsulation, hand weeding twice at 20 and 40 DAS along with weed free treatment and weedy check. Among the various treatments, hand weeding twice at 20 DAS and 40 DAS recorded lower weed index. Among the herbicide treatments, lower weed index and higher weedcontrol efficiency were observed with diclosulam 20 g/ha with encapsulation (T_7). Meanwhile, metolachlor 1 kg/ha with encapsulation (T_8) has recorded higher weed index and lower weed control efficiency during both the seasons. The diclosulam 25g/ha without encapsulation (T_{15}) did not register higher weed control efficiency as that of encapsulated formulations. Higher groundnut productivity was observed with hand weeding twice at 20 and 40 DAS (T_{19}) (1802 kg/ha and 1753 kg/ha pod yield during *Kharif* and late *Rabi* respectively) followed by diclosulam 25 g/ha with encapsulation (T_7) with an average pod yield of 1683 kg/ha and 1636 kg/ha during *Kharif* and late *Rabi* respectively.

Poster 14

Multilanguage mobile app (HerbCal) for herbicide calculations

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Technology is important because it is used in all areas of life. The main forms of technology in industry, farming and household are communication and mobile technology. The best way to deliver information and services to the clients is certainly the use of apps and social media. Mobile applications allow developers to reach a wider audience, in a more cost-effective and personalized manner *i.e.* in retail, banking or healthcare, mobility has transformed into every sector, and now is marching towards the agricultural sector as well. Currently, most of the persons in this world possesses a smartphone. Smartphones combining a range of functions such as media players, camera and GPS with advanced computing abilities and touch screens are enjoying ever-increasing popularity. Smartphones have become a useful tool in agriculture because their mobility matches the nature of farming, the cost of the device is highly accessible, and their computing power allows a variety of practical applications to be created. Smartphones help us to achieve a range of tasks through something known as applications or Apps in short. Agriculture-based mobile apps and technologies help farmers in many ways such as by spreading agricultural-related information to farmers. One of the benefits of such connectivity and information flow is that it helps farmers to make better decisions in their agricultural operations. Uniformly applying chemicals at recommended rates is essential for effective weed management. A slight variation in the application rate with herbicides may result in poor control or injury to the crop or environment, causing lost time, effort and money. Herbicide rates may be given in terms of active ingredient or acid equivalent per acre/ha treated or volume of commercial product per acre/ha. Active ingredient indicates the amount of non-acid herbicide in a formulation. Acid equivalent indicates the amount of an acid herbicide in a formulation. Herbicides may be applied/broadcast (uniformly over the entire field surface) or in bands (narrow strips of herbicide centered over the row, with the area between rows left untreated). Hence, a Multilanguage mobile app namely 'HerbCal' was developed at ICAR–Directorate of Weed Research, Jabalpur. This mobile app was developed in 11 languages *i.e.* Hindi, English, Tamil, Malayalam, Gujrati, Oriya, Marathi, Telugu, Kannada, Bengali and Panjabi. This mobile app works over Android mobile devices for herbicides and water to be applied in desired areas and crops. This app allows users to scout the first language then crop name and identify common dominated weeds of that particular crop with their control measures. This mobile app provides herbicide application-related information to farmers, agriculture department officials, students, other stakeholders and Industry professionals.

Herbicide resistant crops: significance and future perspectives in innovative agriculture age

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Synthetic herbicides use in agriculture blossomed with the advent of selective, auxin herbicides (*e.g.* 2,4-D) in the middle of the last century. Since then, pesticide manufacturers have striven to develop broad spectrum non-phytotoxic herbicides. Over the last half of the 20th century, selective herbicides of different classes, modes of action were discovered, developed and marketed. Some excellent non-selective herbicides were also developed (e.g., paraquat, glufosinate and glyphosate) for use in non-cropped land and/or as protected spray in cropped land. But to use non-selective herbicides in crop field herbicide resistant crops are being developed for broad spectrum weed control using genetically modified (GM) technology that is catered in two ways, *viz.* inoculation of transgene (*e.g.* glyphosate, glufosinate, bromoxynil, 2,4-D, dicamba etc.) and target-site mutation(*e.g.* imidazoline herbicides *i.e.* imazapyr, imazethapyr, imazamox *etc*.), though out of which only two glyphosate and glufosinate herbicide resistant crops are mostly marketed under the brand name of Roundup Ready® and LibertyLink® respectively whereas imidazolinone-tolerant (IT) crops as Clearfield®. Glyphosate, glufosinate and imidazoline herbicides -tolerant (HT) crops were developed by gene modification hence it inhibits EPSPS enzyme, phosphonithrin and ALS inhibiting enzyme respectively. Most GM cultivation in the world is under HT crop (62% as HT trait and 21% as stacked); within this, HT soybean, biotech maize and canola occupy nearly 52%, 31% and 5% respectively of the total biotech crop extent. Glyphosate and Glufosinate- tolerant soybean, maize, cotton, alfalfa and rice and IT maize, oilseed rape, wheat, rice and sunflower etc were developed so far. Major implications of HR crops are capable of excellent weed control capability, reducing numbers of sprays, lesser soil persistence, however, some drawbacks are biodiversity loss, troubles in managing herbicide-resistant volunteers, evolution of herbicide resistant biotypes of existing previously-sensitive species, genetic contamination through gene flow, chances of weed shift, evolution of super weeds *i.e.* weeds become resistant to single herbicide applied and soil organisms may be adversely affected. Perhaps the only conclusion to be drawn from a consideration of the benefits and concerns raised by GM seeds is that neither full-scale adoption nor full-scale rejection is a viable option. The technology may be more appropriate for farmers that have difficulty spraying pesticides and herbicides. Conventional approaches to biocontrol of weeds have had little impact on weed management. Research is under way to improve biocontrol agents with transgenes, but this technology has considerably more environmental risk than herbicide-resistant crops. Research is also underway to make crops more allelopathic with transgene technology, with the hope that herbicide use would be substantially reduced with such varieties. There is concern that introgression of transgenes for this type of trait into wild species could increase fitness in their natural ecosystems, with unpredictable consequences. Since it has been shown that HR systems are not compatible with measures to stop the loss of biodiversity on farmland, a more sustainable model of agriculture is needed with the incorporation of allelopathy transgene as a tool.

A LC-MS/MS based single laboratory validated method for extraction, clean up and quantification of monomer/cross linker of hydrogel in soil matrix

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Pusa Hydrogel, cellulose based and its variant Pusa SPG1118, a clay based super water absorbent polymer of acrylamide. The trace level quantification of acrylamide, acrylic acid and N, N-methylene-bis-acrylamide (MBA), the monomers/cross-linker of those hydrogel, was developed using triple quadrupole LC-MS/MS. During Multiple Reaction Monitoring (MRM) the molecular ions of acrylamide at m/z 72.00 $(M+H)^+$, MBA at m/z 154.85 $(M+H)^+$& acrylic acid at m/z 73.95 $(M+2H)^+$ detected simultaneously only when Acetonitrile was used for standard preparation. The MRM transitions optimized for acrylamide (m/z 72.10>54.95 and 72.10>27.00), acrylic acid (m/z 74.15>41.95) and MBA (m/z 155.10>72.15, 155.10>54.85 and 155.10>83.85), respectively. UPLC equipped with Eclipse Plus C-18 column was eluted with optimized solvent system for 1:1 combination of solvent A [80:20, 5mM ammonium formate solution in water: methanol] and solvent B [10: 90, 5mM ammonium formate solution in water: methanol] at 0.2 mL/min flow and in 5 minutes run the retention times were 2.12, 2.15 & 2.17 min for acrylamide, MBA and acrylic acid, respectively. The most intense MRM transitions viz., m/z 72.10>54.95 for acrylamide, m/z 155.10>72.15 for MBA and m/z 74.15>41.95 for acrylic acid were used as Quantifier and successive transitions were used as Qualifier. Soil samples were extracted by modified QuEChERS technique using acetonitrile extraction. Addition of water manifested significant improvement in recovery of acrylamide and MBA. Single laboratory validation of the developed method in soil matrix was conducted based on specificity, linearity, sensitivity, accuracy, precision, matrix effect and measurement of uncertainty. A linear response obtained for all three monomers/crosslinker in the concentration range of 0.005 to 2 µg/ml in LC-MSMS with correlation coefficient (r)>0.99. Acceptable recovery (within 70-120%) with repeatability (%RSDd”20%) at fortification levels (0.01 to 1 mg/kg) obtained for the analytes from soil matrix. LOQ of the method for acryamide, MBA and acrylic acid in soil matrix were 0.05, 0.01 and 0.01 µg/g, respectively.Both for intra-laboratory repeatability and intermediate precision at LOQ indicate well acceptable precise (HorRatH” 0.3) method for quantification. Matrix enhancement effect (%ME > 100) was observed in the order of acrylic acid > acrylamide >MBA.The Expanded Uncertainty (EU) in soil matrix at LOQ were 21.64%, 19% and 28%, for acryamde, MBA and acrylic acid, respectively. The developed method is time and money-per-sample saving method with trace level sensitivity and high throughput to found suitable to assess the fate of hydrogel/monomer(s) in soil. In real-time sample analysis, we have used the method for analysis soil, where the field crops grown using Pusa hydrogel and Pusa SPG 1118.

Power harrow: One of the best alternatives for control of *Commelina spp* infected soybean field of Malwa region of Madhya Pradesh

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Commelina species, an annual weed, which is propagated by seeds, stem cutting and rooting from the nodes is one of the major weed of kharif season. But, Soybean fields of Malwa region of MP is witnessed to be heavily infested with *Commelina spp.* which has been reported to reduce soybean yield by upto 80%. As Madhya Pradesh is the largest producer of Soybean in India and Malwa region is known as soybean belt, thus *Commelina* spp. is considered to be the major weed of this region. Various herbicide has been used by the farmers to control *Commelina* spp., but it does not respond to any herbicide. Even after the application of mixture herbicides, problem of *Commelina* spp. is not solved as the growth of this weed is arrested for short period but is not fully killed and in later stage it again re-grow or re-germinate. Further, heavy infestation of *Commelina* spp. in soybean field creates problem in field preparation for succeeding crop as this weed remain green even after harvesting of soybean, due to which, harrow or cultivator does not work properly. Because of this, soybean growers need to wait for *Commelina* spp. to dry, which in turn creates the weed seed bank problem due to shattering of seeds into the field. In addition to this, farmers need to run implements 2-3 time more to clean and prepare field, resulting in delaying sowing time of succeeding crop and increase cost of cultivation. Thus, Power harrow is one the best way to control *Commelina spp.*, as it consists of multiple set of blades, counter-rotating about a vertical axis, which chops *Commelina* spp. into small pieces and incorporates into the soil, even at its vegetative stage. Also, it breaks up soil even when fields are heavily infested with this weed and helps in preparing of field in single pass for easy and timely sowing of succeeding crop. Hence, it can be concluded that Power Harrow is the best alternative to control *commelina* spp. as it kills the weed before it matures, incorporate into the soil acting as a manure and helps timely preparation of field for sowing of succeeding crop, which ultimately reduces cost of cultivation.

TECHNICAL SESSION 2

Weed management in cereals-based cropping system

Poster 18

A review of weed management in India: The need of sustainable weed management

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India has a wide range of agro climates and soil types. The highly diverse agriculture and farming systems are beset with different types of weed problems. Weeds cause 10-80% crop yield losses besides impairing product quality and causing health and environmental hazards. Invasive alien weeds are a major constraint to agriculture, forestry and aquatic environment. Crop-specific problematic weeds (eg. weedy rice in rice) are emerging as a threat to cultivation, affecting crop production, quality of product and income of farmers. Traditionally, weed control in India has been largely dependent on manual weeding. However, increased labour scarcity and costs are encouraging farmers to adopt labour and cost saving options such as use of herbicides, whose market grew at an annual rate of 15%. Integrated weed management (IWM) is being practiced by Indian farmers, with the level of adoption varying from one farm to the other. Weeds are the major deterrent to the development of sustainable crop production. The sustainability of agricultural systems is being questioned because of environmental, social, and economic concerns caused by global competition, production cost, soil erosion, environmental pollution, and concern over the quality of rural life. Adoption of sustainable agricultural practices reduces the intensity of soil manipulation thereby creates an unfavourable condition for weed seed germination, reduces the organic matter depletion and soil erosion. Thus, the sustainable approaches could be an option for weed and soil management which leads to sustainable crop production. Enhancing the crop competitiveness through preventive methods, cultural practices, mechanical methods, plant breeding, biotechnology, biological control and crop diversification will be the central thesis in new paradigms of weed management. Integration of above techniques will be key to sustainable weed management that maintain or enhance the crop productivity, profitability and environmental quality. This article explores the scope of sustainable weed management, growing concerns over herbicide resistance, environmental and health hazards of pesticides including herbicides and declining profitability which are the major challenges of 'high input' agriculture. The objective of this review is to suggest the development of ecologically based alternative methods for sustainable weed management that will support crop production systems, which require less tillage, herbicide and other inputs.

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Comparison of the production and weed control efficiency in different rice residue management technologies for wheat

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Rice – wheat cropping system is the most dominant cropping system not only in the Indo- Gangetic plains of India but also in the South Asia. Rice-wheat rotation adopted in Punjab and Haryana, contributed 69 per cent of total grain production with an area of about 2.81 million ha and 15.5 million ha, respectively. Paddy residue management is the main challenge in the *Rabi* season. Various machines are now available for the farmers. Super seeder is becoming popular among the farmers for sowing wheat crop. Super seeder helps plough the standing paddy residue and sow seeds for the next wheat crop, in a single operation. While the happy seeder cuts and lifts rice straw, sows wheat into the soil, and deposits the straw over the sown area as mulch. Clear field in case of super seeder attract the farmers, but in overall performance, happy seeder is better than the super seeder. Thus, in order to assess the effect of these sowing methods, *viz.* happy seeder, super seeder, conventional sowing after complete burning and super seeder with partial burning, on the productivity of wheat, KVK, Amritsar conducted on farm trial on four locations of the Amritsar district during the year 2019-20 and 2020-21. The highest wheat yield was recorded with happy seeder sowing (52.5 and 53.75 q/ha) followed by super seeder (47.65 and 48.75 q/ha), super seeder with partial burning (42.52 and 43.75 q/ha) and conventional sowing (40.52 and 42.50 q/ha). Highest lodging was observed in super seeder (25-30 per cent) and conventional sowing (30-35 per cent) in both years. These paddy residue management methods also help to reduce the herbicide resistance in *Phalaris minor*. Lowest weed population was observed in happy seeder followed by super seeder with full straw load. During the month of March 2022, sudden rise in temperature resulted terminal heat stress in wheat that caused poor wheat yield. But minimum effect of terminal heat stress was also observed in happy seeder sown wheat as the paddy straw mulch lowered the soil temperature. Highest B:C ratio and weed control efficiency was also observed in happy seeder sown wheat.

Effect of sorghum extract and herbicide on weed dynamics and yield of wheat

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A field experiment, on the effect of sorghum extract and herbicide on weed dynamic and yield of wheat (*Triticum aestivum* L.), was conducted at Instructional Farm, College of Agriculture, Jodhpur (Rajasthan) during *Rabi* season of 2021-22. Field experiment was laid out in randomized block design (RBD) with eleven treatments and replicated thrice. As per the treatments, different ratio of sorghum extract was applied either alone at 21 days after seeding (DAS) or with ready-mix herbicide at 30 DAS. The total weed density was influenced by by the effect of sorghum extract sprayed either alone or combined with ready-mix herbicide at all growth stages of wheat except at 30 DAS, where all treatments did not vary significantly. The post-emergence and sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_8) significantly reduced total weed density (4.20, 3.27 and 2.66/m^2) followed by the treatments comprised of its lower concentration *i.e.* sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_7) which also reduced total weed density (5.57, 4.77 and 4.29/m^2 at 60, 90 DAS and at harvest stages of wheat, respectively). The maximum weed control efficiency was with post-emergence and sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_8) followed by the treatment sprayed with sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_7) at all growth stages of crop at their respective sequence which attained highest efficacy, *viz.* 84.76 and 80.58; 88.16 and 83.28 and, 89.85 and 86.88 per cent at 60, 90 DAS and at harvest stages of crop, respectively. Efficacy of different sorghum extract and herbicidal treatments under weed management varied due to their nature and mode of weed control. The minimum losses in yield *i.e.* weed index was associated with post-emergence and sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_8) followed by the treatment sprayed with sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_7) which also showed minimum yield loss in terms of weed index, *viz.* 6.32 and 13.05 per cent, respectively in comparison to weed free. Similarly, significantly higher grain yield (4543 kg/ha.), straw yield (5103 kg/ha.) and biomass yield (9646 kg/ha.) were recorded with post-emergence and sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha (W_8).

Integrated weed management in *Rabi* maize under zero tillage condition

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Maize is an important crop for food, feed and fodder for livestock, raw materials for industries and nutritional security for the many sectors in India. The major yield reducing factors in maize cultivation in India are weed and insects. Weeds cause considerable yield loss due to competition for resources with maize crop. Season long completion reduced the maize grain yield by 70% (Malviya *et. al.* 2012). Therefore, weed management is an important agronomic practice to ensure optimum grain yield. Complete control of weeds is hard to achieve by using any single method of weed control. Continuous use of herbicides for a prolonged time leads to development of resistance in weeds making them difficult to control. However, if various components of integrated weed management are blended in a systematic way, acceptable level of weed control can be achieved. No-tillage maize production conserves soil and water and reduces capital investment in machinery for land preparation and intercultural operations. but No-tillage can improve maize yields. No-till leaves the soil undisturbed from planting to harvest. Adding organic matter through residue can improve soil structure and fertility. Crop residues on the surface of no-till soils may act as insulator, for the decreasing soil temperature and reducing evaporation from the soil surface. Keeping the above facts in view the field experiment was conducted during winter season of the years 2016-2017 to 2017-2018, at crop research from of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. The experiment was designed with ten treatments arranged randomly in randomized block design with three replications. The treatments comprised of: glyphosate1.6 kg/ha 3 days before sowing (DBS); glyphosate1.6 kg/ha 3 DBS followed by (*fb*) power weeder at 25 days after seeding (DAS); pre-emergence application (PE) of halosulfuron 67.5 g/ha; halosulfuron 67.5 g/ha PE followed by power weeder at 25 DAS; atrazine1.5 kg/ha PE; atrazine1.5 kg/ha PE *fb* power weeder at 25DAS; imazethapyer100 g/ha PE; imazethapyer100 g/ha PE *fb* post-emergence application (PoE) of fenoxaprop 100 g/ha at 20-25 DAS; weed free(hand weeding thrice at 20, 40 and 60 DAS and weedy check. Maize hybrid "*DKC 9081*" was used. The soil of the experimental field was clay loam in texture with pH 8.4, EC 0.26 dS/m, medium in organic carbon (0.55%), low in available nitrogen (188 kg/ha), phosphorus (16.71 kg/ha) and potassium (121.25 kg/ha). The highest maize grain yield, net returns and B:C ratio were observed with atrazine1.5 kg/ha PE *fb* power weeder at 25 DAS which was at par with glyphosate1.6 kg/ha 3 DBS followed by power weeder at 25 DAS and halosulfuron 67.5g/ha PE s *fb* power weeder at 25 DAS, respectively.

Critical period of weed control in *Rabi* maize on heavy black soil of south Gujarat

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Maize (*Zea mays* L.) is the third most important cereal crop of India. It is grown for grain as well as for fodder purpose. A field experiment was conducted to find out critical period of weed control in *Rabi* maize at Agronomy farm, Navsari Agricultural University, Navsari, Gujarat during 2015-16 to 2017-18. The experiment was laid out in randomized block design, with 12 treatments of weed interference and replicated thrice. Six treatments of weed free for initial 10, 20, 30, 40, 50 DAS and up to harvest and six treatments of weed infested till initial 10, 20, 30, 40, 50 DAS and up to harvest, were included. The crop was predominated by *Sorghum halepense* L. Pers., *Echinochloa crusgalli* L. Beauv, *Eleusina indica* L. Gaertn., *Dinebra retroflexa, Eragostis minor, Trianthema portulacastrum* L., *Portulaca oleraceae* L., *Euphorbia geniculata* Orteg, *Euphorbia hirta* L., *Amaranthus spinosus, Abutilon indicum, Convolvulus arvensis* L., *Physalis minima* L., *Eclipta alba* Hassak., *Phyllanthus niruri* L., *Alternanthera sessilis* L., *Digera arvensis* Forsk, *Tridex procumbens, Vernonia cinerea, Cyperus rotundus* L. The highest weed control efficiency (WCE) (100%) and lowest weed index (WI) (0%) were recorded with the weed free up to harvest treatment (T_6) while lower WCE and higher WI was with the treatment weedy up to harvest(T_{12}). Significantly higher maize grain yield (5.18 t/ha) was recorded with weed free up to harvest (T_6) in pooled data and it was statistically on par with treatments T_3, T_4, T_5, -T_7 and T_8. Most of the treatments having weedy condition up to 30 DAS or more than that (T_9, T_{10}, T_{11} and T_{12}) as well as weed free up to 20 DAS (T_1 and T_2) recorded lower grain yield. to the maize stover yield was also recorded with weed free up to harvest (T_6). The highest net realization of ₹ 70241/-/ha was obtained in treatment of weedy up to 10 DAS (T_7) followed by treatment T_5 with weed free upto 50 DAS (₹ 69647/-/ha), T_6 with weed free upto harvest (₹ 68117/ha), T_8 with weedy up to 20 DAS (₹ 65354/ha), T_4 with weed free upto 40 DAS (₹ 65236/ha), T_3 with weed free upto 30 DAS (₹ 64671/ha). The B:C ratio value also was higher with the treatment T_7(2.41) followed by treatment T_5(2.39), T_4 (2.24), T_8(2.24), T_3(2.22), T_2(2.15).

Influence of spray fluid quality on weed control efficiency of different post-emergence herbicides and growth parameters in *Rabi* maize

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Among several agronomic constraints for low productivity in maize, weeds constitute one of the major economic problems for maize growers. To achieve optimum performance of herbicides, quality of spray fluid is crucial. Keeping this back drop, a field trial was laid out in factorial randomized block design at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, during *Rabi* 2020-21 with six combinations of post-emergence herbicides + adjuvant applied with 3 different qualities of spray fluids and two external controls replicated thrice to study the impact of spray fluid quality on herbicide performance. Under herbicides + adjuvant factor, treatments included were: post-emergence application (PoE) of tembotrione 120 g/ha + atrazine 0.5 kg/ha without adjuvant as tank mix (H_1), tembotrione 120 g/ha + atrazine 0.5 kg/ha + ammonium sulphate 2% as adjuvant as tank mix (H_2), 2,4-D-Dimethyl amine 0.5 kg/ha without adjuvant (H_3), 2,4-D-Dimethyl amine 0.5 kg/ha + ammonium sulphate 2% as adjuvant (H_4) as tank mix, halosulfuron methyl 67.5 g/ha + atrazine 0.5 kg/ha without adjuvant as tank mix (H_5) and halosulfuron methyl 67.5 g/ha + atrazine 0.5 kg/ha + ammonium sulphate 2% as adjuvant as tank mix (H_6). With respect to quality of spray fluid factor, treatments tested were: C_3S_1 class (EC–0.75 to 2.25 dS/m; SAR–0 to 10) (W_1), C_3S_2 class (EC-0.75 to 2.25 dS/m; SAR–10 to 18) (W_2) and distilled water (W_3) and two external controls were unweeded control (C_1) and weed free plot - hand weeding at 20 and 40 DAS (C_2). Halosulfuron methyl 67.5 g/ha + atrazine 0.5 kg/ha P+ ammonium sulphate 2% as adjuvant as tank mix PoE with C_3S_1 class spray fluid resulted in lowest weed density, weed biomass, highest weed control efficiency (83.72, 70.26 and 62.80% at 30, 60 and 90 DAS) and highest maize leaf area index (2.20 and 3.65 at 60 and 90 DAS), dry matter production (3029, 8567 and 13501 kg/ha at 60, 90 DAS and at harvest) and maize grain yield (5 t/ha and 8.15 t/ha) and was found to be significant over other herbicide combinations with ammonium sulphate as adjuvant with C_3S_1 and C_3S_2 class spray fluids indicating the crucial role of ammonium sulphate as adjuvant in improving the herbicide performance when poor quality saline waters were used as spray fluids.

Unified weed management in *Rabi* pop corn

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The effect of unified weed management in *Rabi* pop corn (Zea mays L.) was studies in College Farm, Navsari Agricultural University, Navsari (Gujarat) during 2017-18. Ten treatments including in weed management practices were evaluated in randomized block design with three replications. Weed free (T_9) recorded maximum yield attributes and yield and was statistically at par with T_6: pre-emergence application (PE) of atrazine 0.5 kg/ha followed by (*fb*) post-emergence application (PoE) of topramezone 0.025 kg/ha at 20 DAS, T_5: atrazine 0.5 kg/ha PE *fb* tembotrione 0.12 kg/ha PoE at 20 DAS and T_4 : atrazine 0.5 kg/ha + pendimethalin 0.45 kg/ha (tank-mix) PE *fb* hand weeding (HW) and inter cultivation (IC) at 40 DAS. Significantly greater grain yield (3748 kg/ha) and stover yield (7898 kg/ha) was registered with T_9: Weed free and it was statistically at par with T_6: atrazine 0.5 kg/ha PE *fb* topramezone 0.025 kg/ha PoE at 20 DAS (3689 and 7614 kg/ha, respectively), T_5: atrazine 0.5 kg/ha PE *fb* tembotrione 0.12 kg/ha PoE at 20 DAS (3575 and 7205 kg/ha, respectively) and T_4: atrazine 0.5 kg/ha + Pendimethalin 0.45 kg/ha tank-mix PE *fb* HW and IC at 40 DAS (3019 and 6544 kg/ha, respectively). The maximum net income was recorded with T_6: atrazine 0.5 kg/ha *fb* topramezone 0.025 kg/ha PoE 20 DAS followed by T_5 and T_4. However, the maximum B: C ratio wasrecorded with T_5: atrazine 0.5 kg/ha PE *fb* tembotrione 0.12 kg/ha PoE followed by T_6: atrazine 0.5 kg/ha *fb* topramezone 0.025 kg/ha PoE and $T_{9:}$ weed free.

Effect of crop establishment methods and weed management practices on weed dynamics, productivity, energy budgeting and soil health in maize-wheat-greengram cropping system

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Weeds are considered to be a major biotic stressor and offer competition to the crops at critical periods resulting in yield loss of up to 37% in crops and cropping systems. Maize-wheat-greengram is an important cropping system that is significantly influenced by weed infestation. Weed severity is largely dependent on management practices such as tillage, crop rotation, crop residue management *etc*. Therefore, the present study was initiated at ICAR-Directorate of Weed Research, Jabalpur (M.P.) to know the effect of crop establishment methods and weed management practices on weed dynamics, productivity, energy budgeting and soil health in maize-wheat-greengram cropping system. The experiment was laid out in a split-plot design and replicated thrice. The main plots were assigned to crop establishment methods [conventional tillage (CT)-CT-CT and zero tillage coupled with previous crop residues (ZTR)-ZTR-ZTR] and in sub-plots weed management practices [weedy check, recommended herbicide (RH), integrated weed management (IWM) and herbicide rotation (HR)]. Based on first-year data, results reveal that adoption of ZTR-ZTR-ZTR recorded a reduction in weed density by 16.9% in maize, 9.6% in wheat and 10.2% in greengram whereas biomass reduction was 22.5, 19.1 and 16.8%, respectively over CT-CT-CT system. Among weed management practices, adoption of HR and IWM was comparable with weed density controlled in maize by 82-99.7% and biomass by 91-99.9% over weedy check. System productivity in ZTR system was higher [14.4 t/ha of maize equivalent yield (MEY)] but was comparable to CT system (14.05 t/ha). System irrigation and water productivity were higher with ZTR system than CT system. System net energy, energy profitability and system profitability were also measured more with ZTR system than that of CT system. In the maize-wheat-greengram system, herbicide rotation controlled all the groups of weeds, whereas adoption of IWM could control the initial flush of weeds. However, imposition of manual weeding disturbs topsoil, hence weeds seeds of the lower layer could come to the surface and established. These resulted in reduction of weed control efficiency though their biomass accumulation was considerably low. Among weed management practices, adoption of integrated weed management [pre-emergence application (PE) of pendimethalin 500 g+ atrazine 500 g/ha followed by (*fb*) hand weeding (HW) in maize – clodinafop+metsulfuron 60+4 g/ha *fb* HW in wheat- pendimethalin 678 g/ha *fb* HW in greengram] obtained highest system productivity in terms of MEY, system irrigation and water productivity, productivity and system profitability these were followed by HR. It was noticed that system net energy was higher with HR but was comparable to IWM. All system indices were lowest with weedy check. Use of herbicides with a different mode of action did not allow the weeds to establish in the long run thus fewer weeds could be established with HR adoption. Therefore, it can be concluded that the adoption of ZTR system with either herbicide rotation or integrated weed management will provide better weed control, higher system crop-water and energy productivity and profitability in maize-wheat-greengram cropping system.

Integrated weed management practices on quality and economics of wheat

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An experiment was conducted during *Rabi* 2021-22 at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule. Experiment consisted of nine treatments laid out in randomized block design with three replications. Different weed control treatment has significantly influenced the weed population, quality and economics of wheat. All the growth parameter of wheat, *viz.*, plant height (cm), number of tillers (m^{-2}) and total dry matter accumulation per plant, were significantly higher in weed free check. Among the different weed management treatments, pre-emergence application (PE) of pendimethalin 1.0 kg/ ha followed by (*fb*) hand weeding (HW) twice at 20 and 40 days after seeding (DAS) recorded significantly higher in quality and economic parameters and it was par with pendimethalin 1.0 kg/ ha PE *fb* post-emergence application (PoE) of metsulphuron-methyl *fb* one HW at 40 DAS. The significant effect on quality and economic character of plant was noticed due to different treatments which resulted in enhance quality contributing character, *viz.*, protein in (%) and protein yield (kg/ha). The highest protein (%) and protein yield (kg/ha) of wheat were recorded in weed free check (12.12 and 6.62, respectively) and among various weed management treatments, relatively higher protein (%) and protein yield (kg/ ha)was observed with pendimethalin 1.0 kg/ ha PE *fb* HW twice at 20 and 40 DAS and it was found at par with pendimethalin 1.0 kg/ ha PE *fb* metsulphuron-methyl PoE *fb* one HW at 40 DAS due to the significant reduction in weed density and biomass, thereby reduction in crop-weed competition. Elimination of weeds during early crop growth stages resulted in better plant growth and yield. Among the integrated weed management treatments, weed free recorded higher gross return and net return. Benefit cost ratio was maximum in weed free (2.52) followed by pendimethalin 1.0 kg/ ha PE *fb* metsulphuron methyl PoE *fb* one HW at 40 DAS (2.51).

Tillage and mulch load influences weed severity, system productivity, and root and soil cracks behaviour in rice-wheat-greengram cropping system

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In conventional agriculture, sustainability is under threat where biotic stresses play a crucial role. Conservation agriculture-based practices like minimum soil disturbance, retention of previous crop residue, and crop diversification are solutions to maintain agriculture sustainability. Weeds are major biotic constraints to agricultural production, causing significant agronomic and economic damage by 37%. Weeds are most commonly controlled with herbicides, although non-chemical methods are also essential components of integrated weed management strategies. Rice-wheat-greengram cropping system (RWGCS) is an important cropping system that is significantly influenced by weed infestation. The present study was conducted at ICAR-Directorate of Weed Research, Jabalpur (M.P.), India during 2017-2020 to quantify the effect of tillage and mulch load on weed severity, system productivity, root and soil cracks behaviour in RWGCS. The experiment was laid out in split-plot design and replicated thrice. Themain plots were assigned to tillage, *viz.* conventional (CT) and conservation (ZT) and sub-plots to previous crop residue loads (CRL), *viz.* no mulch, 2 t/ha, 4 t/ha and 6 t/ha, CRL. The ZT plots were infested more with grassy weeds by 11.7-33.6% in wheat, 23.5-47.1% in greengram, and 32.3-46.2% grasses and ~31% sedges in rice over CT. Contrarily, broad-leaved weeds were lower in ZT by 7.6-20.8% in wheat, 24.5-52.3% in greengram, and 9.5-16.2% in rice than in the CT. Placement of CRL at 6 t/ha significantly suppressed the weeds and recorded lower weed density and biomass, whereas the highest weed density and biomass were recorded without CRL. Despite variation in weed severity, the highest system productivity in terms of rice equivalent yield was obtained with ZT (10.3 t/ha) which was 4.2% higher than CT. Likewise, placement of CRL at 6 t/ha recorded 11.1 t/ha system productivity which was 30.2% higher than without CRL. Roots parameters in ZT were more concentrated near the soil surface (0-15 cm) by 26-32% more number, 18-40% higher volume, and 11-35% heavier roots, whereas in deeper layer (15-30 cm) CT has better root parameters (7-19% longer, 43-89% more number, 4-49% higher volume and 34-87% heavier). Among CRL, more root parameters were recorded without CRL at 0-15 and 15-30 cm soil profile, irrespective of crops. Soil crack volume (SCV) and soil crack surface area (SCSA) were observed to be lesser by 27-67 and 32-65%, respectively in ZT. But the adoption of CRL at 6/ha reduced SCV considerably by 2-12.4 times and SCSA by 3.4-7.9 times over without CRL. Thus, by ZT along with 6 t/ha of crop residues results in lower weed pressure and higher system productivity with fewer soil cracks in RWGCS. This is a pioneering study, as the quantification of CRL to be retained for optimum weed suppression and higher yield under different tillage in system mode is unavailable yet to policymakers.

Integrated weed management in *Rabi* pop corn with new generation herbicides

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Effects of "Integrated Weed Management in *Rabi* pop corn (*Zea mays* L. var. *everta*) under South Gujarat conditions" were evaluated in College Farm, Navsari Agricultural University, Navsari (Gujarat) on species wise weed count (per m^2), dry weight of weed at harvest (kg/ha), Weed Control Efficiency (%), Weed Index (%), grain and stover yield (kg/ha) in *Rabi* pop corn during 2017-18. The experimental soil was clayey in texture, low in available nitrogen (164 kg/ha), medium in available phosphorus (42 kg/ha) and high in available potash (315 kg/ha). Results revealed that the significantly minimum number of monocot (*Cynodon dactylon* L., *Sorghum halepense* L., *Dactyloctenium aegyptium*, *Echinochloa colona* L. and *Brachiaria ramose* L.), dicot (*Euphorbia hirta* L., *Chenopodium album* L., *Digera arvensis* Forsk, *Physalis minima* L., *Phyllanthus niruri* L., *Amaranthus viridis* L., *Alternanthera sessilis* L. and *Portulaca oleracea* L.), sedge weed (*Cyperus rotundus* L.), dry weight (148.52 kg/ha) of weeds at harvest, weed index (1.57%) and highest weed control efficiency (36.30%) were recorded under the weed control through treatment atrazine 0.5 kg/ha *fb* Topramezone 0.025 kg/ha as post-emergence at 20 DAS), *fb* treatment atrazine 0.5 kg/ha*fb* Tembotrione 0.12 kg/ha as post-emergence at 20 DAS. While, significantly the maximum monocot, dicot, sedge weeds, dry weight (233.17 kg/ha) of weeds at harvest, weed index (58.17%) and lowest weed control efficiency (0) were recorded under unweeded control at 30 DAS, 60 DAS and harvest. Significantly greater grainyield and stover yield (3748 and 7898 kg/ha, respectively) were registered with weed-free but it was statistically at par with atrazine 0.5 kg/ha *fb* Topramezone 0.025 kg/ha as post-emergence at 20 DAS), atrazine 0.5 kg/ha*fb* Tembotrione 0.12 kg/ha as post-emergence at 20 DAS andatrazine 0.5 kg/ha + pendimethalin 0.45 kg/ha tank- mix as pre-emergence *fb* HWand IC at 40 DAS. The maximum net returns was gained from atrazine 0.5 kg/ha *fb* topramezone 0.025 kg/ha as post-emergence at 20 DAS followed by atrazine 0.5 kg/ha*fb* Tembotrione 0.12 kg/ha as post-emergence at 20 DAS and atrazine 0.5 kg/ha + pendimethalin 0.45 kg/ha tank- mix as pre-emergence *fb* HWand IC at 40 DAS. however, the maximum B: C ratio was recorded by atrazine 0.5 kg/ha*fb* Tembotrione 0.12 kg/ha as post-emergence at 20 DAS and atrazine 0.5 kg/ha followed by atrazine 0.5 kg/ha *fb* topramezone 0.025 kg/ha as post-emergence at 20 DAS and weed free. Based on results of the field experiment, it can be concluded that potential production and effective weed control in *Rabi* pop corn can be achieved by keeping weed free condition by hand weeding and inter-culturing during crop growth period. When labours are not easily available, another alternative is pre-emergence application of atrazine 0.5 kg/ha *fb* topramezone 0.025 kg/ha as post-emergence at 20 DAS or tembotrione 0.12 kg/ha (as post-emergence) also equally cost-effective to achieve potential and profitable maize production.

Poster 29

Organic weed management in major field crops

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Farmers have struggled with the presence of weeds in their fields since the beginning of agriculture. Weeds can be considered a significant problem because they tend to decrease crop yields by increasing competition for water, sunlight, and nutrients while serving as host plants for pests and diseases. Since the invention of herbicides, farmers have used these chemicals to manage weeds in their fields. Using herbicides not only increased crop yields but also reduced the labor required to remove weeds. Despite weeds are a serious threat to promotion of organic farming, relatively less attention is given to research on weed management. Organic weed management is a holistic system involving an entirely different approach to managing a farming system. The organic farmer is not interested in eliminating all weeds but wants to keep the weeds at a threshold that is both economical and manageable. A farmer who manages weeds organically must be intimately familiar with the type of weeds and their growth habits to determine which control methods to employ. Various weed management practices in organic farming explores a scope of integration of conservation agriculture. Limitation in the use of agro-chemicals under organic farming promotes intensive tillage for weed control. Effective weed management on organic farms requires extensive planning and preventing measure coupled with cultural method and crop rotations are the basis for successful organic farming and are necessary for breaking weed, insect and disease cycles. Diverse weed flora (grasses, sedges and broad leaves weeds) and excessive weed pressure is an important constraint in the way to sustainability and production potential of rice-wheat cropping system. Rainy season crops, faces severe weed competition during early stages of crop growth, resulting in loss of about 40-60% of the potential yield, depending on the weed intensity, nature, environmental condition and duration of weed competition. Appropriate crop rotations and cover crops management suppress weeds populations with smothering and allopathic effects. Bio control and understanding of allele-chemical may help the organic farming. The existences of weeds in cropped lands are largely influenced by crop rotation and management practices. The surface application of mulch favorably influences the weed flora by suppressing their emergence and subsequent growth, and may also provide the nutrients by microbial decomposition of organic mulches. Number of secondary metabolites / allelomones is being screened for herbicidal properties from different plants with considerable crop selectivity, which can be used directly in the form of aqueous plant extracts and indirectly gives clues for developing analogs of herbicides. Thus, cultural approaches integration under organic farming could be an option for weed, pest and soil management which leads to sustainable organic plant production. Monitoring weed growth stages is also critical in determining ideal cultivation times.

Bio-efficacy of pinoxaden on weeds and yield of wheat

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A field experiment entitled "Bio-efficacy of Pinoxaden on Weeds and Yield of Wheat" was conducted during *Rabi* 2020-21 under AICRP on wheat in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP). The experiment was laid out in randomized complete block design with seven integrated weed control treatments comprising of pinoxaden 40 g/ha, pinoxaden 45 g/ha, pinoxaden 90 g/ha, clodinafop propargyl 60 g/ha, sulfosulfuron25 g/ha and hand weeding (30 DAS) and weedy check.The wheat variety *MP-3382was seeded* with a seed rate of 100 kg/ha and spacing (R×R) 20 cm. The weed flora associated with wheat crop in experimental field was dicots *Medicago denticulate* (30.82%), *Cichorium intybus* (29.94%), *Chenopodium album* (15.32%) and *Anagalis arvensis* (8.30%) among the broad leaved weeds and *Phalaris minor* (15.59%) was only among the grassy weed.Maximum weed control efficiency(89.28%) at 30 DAS was registered under hand weeding at 30 DAS followed by pinoxaden 90 g/ha with weed control efficiency of (41.12%) followed by pinoxaden 45 g/ha (37.70%) respectively at 30 DAS. The growth parameters (plant height, number of tillers/m^2, LAI and crop biomass), yield attributing traits (effective tillers/m^2, ear head length, grains per ear head and test weight), grain and straw yields attained the maximum values under hand weeding followed by application of pinoxaden 45 g/ha.Post-emergence application of pinoxaden 90 g/ ha, registered some improvement in these parameters to that of pinoxaden 45 g/ha, sulfosulfuron 25 g/ha, clodinafop propargyl 60 g/ha and pinoxaden 40 g/ha. However, there was identical improvement in the values of all the yield attributing traits. But none of the herbicidal treatments excelled to hand weeding which had the maximum value of these yield attributing traits. Post-emergence application of pinoxaden 45 g/ha caused significant improved in grain and straw yields followed by clodinafop propargyl 60g/ha, sulfosulfuron 25 g/ha, pinoxaden 45 g/ha and pinoxaden 40 g/ha being higher under yield attributing traits. However, hand weeding treatment surpassed all the herbicidal treatments in terms of grain and straw yields on account of superior values of yield attributing traits. Application of pinoxaden 45 g/ha found more remunerative as it received higher value of net return (₹ 80550/ha) and higher B:C ratio (2.89) respectively, relative to other treatments.

Impact of sustainable weed management practices under varied nutrient management practices in maize

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A field experiment was conducted during two consecutive *Kharif* seasons of 2019-20 and 2020-21 on sandy loam soils of S.V. Agricultural College, Tirupati, Andhra Pradesh. The field experiment was laid out in a split plot design with three replications. The treatments comprised of four nitrogen management practices, *viz.*, control, recommended dose of fertilizer, green seeker directed N application and soil test-based fertilizer application assisnged to main plots. and nine weed management practices, *viz.*, unweeded check, hand weeding twice at 15 and 30 DAS, pre-emergence application of atrazine 1.0 kg/ha *fb* post-emergence application of topramezone 30 g/ha, pre-emergence application of atrazine 1.0 kg/ha *fb* post-emergence application of tembotrione 120 g/ha, application of parthenium water extract15 l/ha twice at 15 and 30 DAS, application of sunflower water extract 15 l/ha twice at 15 and 30 DAS, pre-emergence application of atrazine 1.0 kg/ha *fb* post-emergence application of parthenium water extract 15 L/ha, pre-emergence application of atrazine 1.0 kg/ha *fb* post-emergence application of sunflower water extract 15 L/ha and brown manuring. The predominant weed species noticed in the experimental field were *Cyperus rotundus* L., *Digitaria sanguinalis* (L.) Scop., *Dactyloctenium aegyptium*(L.) Willd., *Blainvillea acmella* L., *Lagasce amollis*Cav. and *Commelina benghalensis*L. Among Nutrient management practices, recommended dose of fertilizer and green seeker directed N application were at par with each other and were significantly lower than soil test based fertilizer application, which recorded significantly higher density and lower WCE.With regard to weed management practices studied, at 20 DAS, two hand weedings at 15 and 30 DAS recorded significantly lower weed dry weight with higher WCE. The next best treatments in suppressing the weed count were atrazine 1.0 kg/ha (PE) + topramezone 30 g/ha or tembotrione 120 g/ha (PoE), atrazine 1.0 kg/ha (PE) + sunflower water extract 15 L/ha (PoE) or parthenium water extract 15 L/ha (PoE) without any significant disparity among them but recorded statistically lower dry weight and higher WCE than brown manuring.Higher dry weight and lower WCE were recorded in unweeded check (W_1), which was however, comparable with application of sunflower or parthenium water extract 15 l/ha twice at 15 and 30 DAS.At 40 DAS, hand weeding twice at 15 and 30 DAS was in parity with atrazine 1.0 kg/ha (PE) + topramezone 30 g/ha or tembotrione 120 g/ha (PoE).Brown manuring was the next best weed management practice in reducing the dry weight of weeds with higher WCE. Atrazine 1.0 kg/ha (PE) + sunflower water extract 15 L/ha (PoE) or parthenium water extract 15 L/ha (PoE) were comparable with one another and were significantly lower than application of sunflower or parthenium water extract 15 l/ha twice at 15 and 30 DAS.

Efficacy of herbicides and their combinations on weeds and effect on growth and yield of maize in North-Western Himalayan region of Himachal Pradesh

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Maize (*Zea mays* L.) or 'Queen of Cereals' is the third most important cereal crop, after rice and wheat, in India. The multiple uses of the crop for food, fodder, and fuel have led to a sharp increase in its demand as a high-value crop. Although India attained food security post-green revolution, there are some countries where maize forms the basis of food security such as Africa. Across the globe, maize production was 1162 million hectares from an area of 201 million hectares with a productivity of 5.75 t/ha in 2020. In India (2020), maize was cultivated in an area of 9.86 million hectares with a production of 30.16 million tonnes and productivity of 3.06 t/ha. The state of Himachal Pradesh (2019) relies on rainfall for water and although rainfall is becoming erratic due to climate changes, the maize-wheat cropping system still emerges as the major cropping system of the state with an estimated area of 287 thousand hectares and production of 726 thousand metric tonnes. In crop production systems, weeds are the one of the biotic stressors competing for space, nutrients, light, and water resulting in significant yield losses from 51 to 100%. To sustain crop production, herbicide applications have become standard practice. Keeping this in view, a field experiment was conducted to evaluate the efficiency of herbicides and their combinations for the control of weeds at CSK HPKV-Hill Agricultural Research and Extension Centre, Bajaura, Kullu, Himachal Pradesh, India. The farm is located at a longitude of 77° E and latitude of 31°8' N with an elevation of 1556 m AMSL. The experiment comprised nine treatments and three replications in a randomized complete block design. The treatments are weedy check, weed free, atrazine 1000g/ha (PE) *fb* hand weeding 25DAS, atrazine 750g/ha (PE) *fb* topramezone 25.2 g/ha at 25DAS, atrazine 750g/ha (PE) *fb* tembotrione 120 g/ha at 25DAS, atrazine 1000g/ha (PE) *fb* topramezone 25.2 g/ha at 25DAS, atrazine 1000 g/ha (PE) *fb* tembotrione 120 g/ha at 25 DAS, topramezone 25.2 g/ha + atrazine 750 g/ha at 15DAS, and tembotrione 120 g/ha + atrazine 750 g/ha at 15 DAS. In terms of yield attributes such as plant population and cobs/ha, no significant differences were observed with the herbicide treatment. On the other hand, plant height and seed index were significantly influenced with the highest under topramezone 25.2 g/ha + atrazine 750 g/ha at 15DAS and tembotrione 120 g/ha + atrazine 750 g/ha at 15DAS, respectively. The spray of topramezone in combination with atrazine at the recommended rate of 25.2 g/ha + 750 g/ha has been effective in controlling the weed by 88.7%. Significant reductions in the weed dry matter were also recorded under topramezone 25.2 g/ha + atrazine 750g/ha at 15 DAS thereby giving a higher grain yield of 7.99 t/ha in maize.

Organic weed management in sweet corn

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Sweet corn (*Zea mays* L.) is generally grown for fresh green cobs for human consumption and it is also used as raw and processed material for the food industry. It is an important source of dietary fiber, minerals and certain vitamins like A and C. Its taste and nutritional value have made it a valued crop all over world and the scope of sweet corn production is constantly increasing. As part of the 1990 Farm Bill, the U.S. Department of Agriculture's National Organic Program (NOP) was created to establish national standards and mandatory certification for organically grown products. Producers, who meet NOP standards and are certified through annual onsite inspections by licensed certified inspectors, may label their products as "USDA Certified Organic." Production systems that are certified organic integrate cultural, biological, and mechanical practices that foster cycling of resources; promote ecological balance; and conserve biodiversity without the use of synthetic pesticides, GMO, or other specified products. Certified organic foods generally receive higher selling prices than nonorganic foods. A two years field experiment was conducted at the Instructional Farm, RCA, MPUAT, Udaipur, during *Kharif* 2018 and 2019 with 12 treatment combinations (Summer ploughing + 1 hand weeding at 20 DAS, Summer ploughing + straw mulch (5 t/ha) at 20 DAS+1 hand weeding at 40 DAS, Summer ploughing + plastic mulch at sowing, Stale seed bed preparation + 1 hand weeding at 20DAS, Stale seed bed preparation + straw mulch (5 t/ha) at 20 DAS+1 hand weeding at 40 DAS, Stale seed bed preparation + plastic mulch at sowing, Soil solarization + 1 hand weeding, Soil solarization + straw mulch (5 t/ha) at 20 DAS+1 hand weeding at 40 DAS, Soil solarization + plastic mulch at sowing, *Sesbania* as smothering crop in between rows and used same Sesbaina as mulch after 30 days + 1 hand weeding at 40 DAS, Pendimethalin 1000 ml /atrazine 500g fb straw mulching (5 t/ha) at 20 DAS and Weedy check in randomized block design with three replications. For plastic mulch, polythene sheet of black colour with 25-micron size was used. In one ha, 11 kg polyethene sheet was used. The final validity of any new agro-technology in weed management system is validated by its relative economics over the conventional practices, both in terms of net profit and benefit cost ratio (B:C) ratio. Among organic weed management practices, highest net return (¹ 62746/ha) and BC ratio (1.62) were recorded with stale seed bed and plastic mulch, whereas in 2019 highest net return (¹ 108825/ha) was obtained with soil solarization and plastic mulch, whereas maximum B:C ratio (2.35) was recorded with stale seed bed technique and plastic mulch.

Effect of irrigation scheduling on weeds under different sowing dates in wheat in vertisol

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Wheat (*Triticum aestivum* L.) is sown from mid- November to end of December in central India. In recent years, sowing gets delayed due to addition of garden pea in the cropping system, as a catch crop after harvesting of *Kharif* pulses. This delay affects the sowing window, and it is also vulnerable to temperature conditions. Late *Rabi* sowing may lead to reduced crop growth duration, as phenological stages were not compatible with delayed weather conditions. Beside this, it also affects weed density thereby competes with the main crops. The impact of late sowing can be alleviated with irrigation regimes up to some extent, however, the role of weeds under different thermal environments and irrigation schedules need to be assessed out. Hence, a field experiment was conducted during the *Rabi* season of 2020-21 year at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, M.P. with an aim to assess the effect of irrigation scheduling on weeds under different sowing dates in vertisol. The experiment was laid in a split-plot design with three replications, comprising three dates of sowing (D_1- December 03, D_2- December-18, D_3-January- 02) as main plots and four irrigation levels based on Irrigated Water/Cumulative Pan Evaporation (IW/CPE) ratio (I_1- 1.0, I_2- 0.9, I_3- 0.8 and I_4- 0.7) in sub-plots. Weed density and biomass were analysed at 30 and 60 days after applying herbicide (DAA), and at harvest. The total weed density (3.68, 2.40 and 2.37/m^2 at 30 and 60 DAA and at harvest, respectively) and total weed biomass (2.19, 2.08 and 1.94 g/m^2 at 30 and 60 DAA, and at harvest, respectively) was observed more in December 03 sown crop as compared to late sowing. This might be due to congenial weather conditions for good germination and growth that helps to established easily than delayed sowing. Similarly, with IW/CPE ratio 1.0 more total weed density (3.72, 2.47 and 2.38 /m^2 at 30 and 60 DAA, and at harvest) and total weed biomass (2.22, 2.11 and 1.94 g/m^2 at 30 and 60 DAA, and at harvest) were observed than with the other IW/CPE ratio. The efficiency to control weeds were analyzed between 1.0 IW/CPE as control and the other irrigation schedules at different sowing dates. There were no significant differences among different sowing dates in controlling weeds. The irrigation schedules caused significant differences at 30, 60 and 90 DAA. The IW/CPE ratio 0.9 schedule recorded less weeds, as more irrigation caused greater occurrence of weeds. Crop sown on December 03 recorded maximum wheat grain yield (4.64 t/ha) as compared to delayed sowing. Among irrigation schedule, 1.0 IW/CPE recorded maximum wheat grain yield (4.51 t/ha) than other treatments.

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Chemical weed control in barley

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Barley (*Hordeum vulgare* L.) is an important crop which is grown for grain and malt purpose in India. Weed management is essential for better grain yield due to their competition for nutrients, water, space and sunlight. The yield reduction in barley depends upon the type and density of associated weed flora. Among the grass weeds, wild oats (*Avena ludoviciana*) can cause yield reduction in irrigated barley from 15-50%. Similarly, *Chenopodium album*, *Lepidium sativa*, *Anagallis arvensis* and other broad-leaved weeds also compete with this crop causing yield reduction up to 25%. The application of 2, 4-D for the control of broad-leaved weeds in wheat seems to be less effective against some broad-leaved weeds. The post-emergence herbicide pinoxaden at 40-60 g/ha was very effective against *Avena ludoviciana* and resistant population of *Phalaris minor* without any phytotoxicity to barley both grass and broad-leaved weeds are becoming problem in barley crop. Therefore, there was dire need to test some broad-spectrum herbicides so that effective weed control can be achieved in barley. A field experiment was conducted during the *Rabi* season of 2018-19 on sandy loam soils to identify the effective herbicides for weed control in barley. The treatments were laid out in split-plot design with two varieties, *viz.* '*PL-426*' and '*DWRUB-52'* in main plots and different herbicide combinations, *viz.* pinoxaden 40 g/ha 35 days after seeding (DAS) (T1), pinoxaden 50 g/ha 35 DAS (T2), pinoxaden + metsulfuron 40 + 4 g/ha 35 DAS (T3), pinoxaden + metsulfuron 50 + 4 g/ha 35 DAS (T4), metsulfuron *fb* pinoxaden 4 *fb* 40 g/ha (T5), metsulfuron *fb* pinoxaden 4 *fb* 45 g/ha (T6), metsulfuron *fb* pinoxaden 4 *fb* 50 g/ha (T7), pinoxaden + carfentrazone 40 +20 g/ha (T8), pinoxaden + carfentrazone 50 + 20 g/ha (T9), carfentrazone 20 g/ha (T10), weed free (T11) and control (T12) in sub plots with three replications. The field had infestation of both grasses and broad-leaved weeds, with the dominance of *Phalaris minor, Avena ludoviciana, Melilotus indica, Chenopodium album, Chenopodium murale, Euphorbia helioscopa, Anagallis arvensis, Spergula arvensis, Convolvulus arvensis, Coronopus didymus, Rumex dentatus, Asphodelus tenuifolius, Cirsium arvense, Lathyrus aphaca* and *Vicia sativa*. The highest plant height was recorded with metsulfuron *fb* pinoxaden 4 *fb* 50 g/ha (T7) and it was at par with other herbicide combinations. Metsulfuron *fb* pinoxaden 4 *fb* 50 g/ha (T7) gave maximum number of tillers/m length which was significantly higher than application of pinoxaden 50 g/ ha (T2) and pinoxaden+ metsulfuron 40 + 4 g/ha (T3). The number of grains/spikes was maximum with pinoxaden + metsulfuron 50 + 4 g/ha (T4) and significantly higher than with pinoxaden + carfentrazone 40 + 20 g/ha (T8), pinoxaden + carfentrazone 50 + 20 g/ha (T9), weed free (T11) and control (T12) and statistically at par with other herbicide combinations. The maximum grain yield (3.39 t/ha) was recorded in pinoxaden + metsulfuron 50 + 4 g/ha (T4), at par with other herbicide combinations.

Sole and sequential application of herbicides on weeds and productivity of *Kharif* maize

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Maize is an important cereal crop grown for food, feed and industrial purpose in the world and it occupies third position after rice and wheat in India. Maize will be third most popular food crop after wheat and rice to feed the continuously increasing population of the world. Because the productivity of maize is higher than the rice and wheat and C_4 plant has higher adaptability to the environment. Nevertheless, maize productivity is affected by the weeds due to high competition between the crop and weed in early growth stage of crop. The weed pressure on crop is the most conspicuous in rainy (*Kharif*) season due to 2-3 flushed of weed during crop duration. Therefore, study of weed control using the herbicides is needed to sustain the productivity of maize. In this experiment three type herbicides have been used viz; atrazine, topramezone and tembotrione in which all are broad spectrum herbicides but atrazine alone is less effective due to application as a pre-emergence and it could not manage the weeds up to harvesting stages or second and third flushes of weeds. A field trial was conducted during the rainy season 2019 at Agricultural Research farm of TCA Dholi under the RPCAU Pusa, Samastipur (Bihar). The treatment pre-emergence application (PE) of atrazine 1 kg/ha *fb* post-emergence application (PoE) of tembotrione 120 g/ha at 25 days after seeding (DAS) had given the excellent result in comparison to other treatments. It reduced the weed population and biomass of weed up to harvesting stage, though; weed free was superior from the all treatments. Mixed application of topramezone 25.2 g/ha and tembotrione 120 g/ha with atrazine 0.75 kg/ha applied at 15 DAS reduced the weed density and biomass up to 25 DAS but thereafter this atrazine 1 kg/ha *fb* tembotrione 120 g/ha at 25 DAS was superior than all tested herbicides. Weed-free condition obtained maximum grain and straw yield (6.42 t/ha and 8.79 t/ha) in comparison to all other treatments but among all the herbicides tested, atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE at 25 DAS recorded significantly higher grain yield and straw yield (6.24 t/ha and 8.61 t/ha) compared to other treatments. The nutrients (59.61% N, 63.04% P and 65.86% K uptake in weed free was more than weedy check. In weedy check weed uptake had the highest nutrients uptake. The nutrient uptake by crop was improved and uptake by weed was reduced with atrazine 1 kg/ha PE *fb* tembotrione 120 g/ha PoE at 25 DAS. The highest gross return was with weed-free (₹ 130512 ₹/ha). But, maximum net return (₹ 92539/ha) and higher benefit cost ratio (2.68) were recorded with the atrazine 1 kg/ha PE *fb* tembotrione 120 g/ha at 25 DAS It may be concluded that atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE at 25 DAS effectively controlled the weeds thereby enhanced the productivity and cost-effective weed control practice for maize crop.

Weed assessment under different fertilizer and irrigation levels among sowing dates in wheat

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Wheat is the second most important staple food crop after rice in India however; the introduction of high yielding varieties coupled with increased use of fertilizer and irrigation levels promote weed density. These species density also varies at different sowing time, as they may be affected by thermal environment. On this basis, a field experiments were carried out during the *Rabi* seasons of 2015-16 and 2016-17 years at JNKVV, Jabalpur, M.P. to assess weed density and biomass under different fertilizer requirement and irrigation levels among different sowing dates. Three sown dates (D1=2 Dec., D2=22 Dec, D3=12 Jan.) with two irrigation schedules (I1=3 irrigation at CRI, spikelet and milk; I2=4 irrigations at CRI, joint, spikelet and milk stages) and four fertilizer applications (F1=Control, F2=60:30:20, F3=120:60:40, F4=180:90:60 kgNPK/ha) were arranged in a split plot design. Weed density and biomass was observed at 30 DAS among all the plots in both the years. Among the sown dates, D1 observed significantly higher weed density (10.1/m^2) than D2 (8.6/m^2) and D3 (6.7/m^2) dates. Similarly, I1 (8.2/m2) and I2 (8.75/m^2) schedules exhibited a non-significant difference in total weed density. Fertilizer application of F3 (8.65 /m^2) and F4 (9.2/m^2) exhibited significantly higher weed density than F2 (8.3/m^2) application; the F2 was significantly not different from F1 (7.8/m^2) application. Among the weed biomass, D1 observed maximum weed biomass (2.7 g/m^2) than D3 (1.83 g/m^2) sown dates. The irrigation schedule, I2 exhibited significantly higher weed biomass (2.3 g/m^2) than I1 (2.2 g/m^2). The F4 observed significantly higher weed biomass (2.48 g/m^2) that was significantly higher than F1 (2.1 g/m^2) fertilizer applications. This suggest that wheat sown early with recommended F3 application expected more total weed density than sown late thereby suggested that weed occurrence and germination were influenced by early sown favorable weather conditions with optimum fertility treatments. The more frequencies of irrigation and fertilizer applications supported more weed density and biomass.

Efficacy of herbicides against complex weed flora in maize

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Maize is an important crop having high production potential. Since, it is a wide spaced crop; weed interference is one of the major concerns. Weeds, in general reduce the maize yield by 27-60% depending upon the growth and persistence of weed population in maize crop. Thus, weed management is an important aspect for successful and profitable crop production. Manual weeding is time consuming, labour intensive and uneconomical. Therefore, weed control with herbicides is one of the options. Thus, an experiment was conducted at Agricultural Research Station, Sardarkrushinagar Dantiwada Agricultural University, Ladol on sandy loam soil during *Kharif* 2019 to 2021 to assess the efficacy of herbicides against complex weed flora in maize. The experiment was conducted in randomized block design with three replications. Maize variety '*GAYMH 1*' was sown at 60 cm x 20 cm spacing. There were ten treatments, *viz.* atrazine 1000 g/ha as pre-emergence application (PE), topramezone 30 g/ha as post-emergence application (PoE) at 20 DAS, tembotrione 150 g/ha as PoE at 20 DAS, atrazine 1000 g/ha as PE followed by (*fb*) halosulfuron 67.5 g/ha as PoE at 25 DAS, atrazine 750 g/ha as PE *fb* topramezone 25 g/ha as PoE at 20 DAS, atrazine 750 g/ha as PE *fb* tembotrione 125 g/ha as PoE at 20 DAS, atrazine 750 g/ha + topramezone 25 g/ha as PoE at 15 DAS (tank-mix), atrazine 750 g/ha + tembotrione 125 g/ha as PoE at 15 DAS (tank-mix), weed free and weedy check. Major weed flora observed in the experimental field was *Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Digera arvensis, Amaranthus lividus, Euphorbia hirta, Phyllanthus niruri, Vicia sativa* and *Argemone mexicana.* Pooled data of three years indicated that, among the different treatments, significantly higher grain and stover yield (2.89 and 6.99 t/ha, respectively) recorded under weed free plot followed by atrazine 750 g/ha as PE *fb* tembotrione 125 g/ha as PoE at 20 DAS (2.80 and 6.79 t/ha, respectively) and atrazine 750 g/ha as PE *fb* topramezone 25 g/ha as PoE at 20 DAS (2.76 and 6.56 t/ha, respectively). These three treatments remain statistically at par. Pooled result indicated that all the weed control treatments significantly reduced the weed density as well as weed biomass over weedy check plot. After weed free plot, maximum weed control efficiency at 60 DAS was reported with atrazine 750 g/ha as PE *fb* tembotrione 125 g/ha as PoE at 20 DAS (63.3%) followed by atrazine 750 g/ha as PE *fb* topramezone 25 g/ha as PoE at 20 DAS (58.0%). Weed index varied from 0 to 23.7% in weed free and weedy check plot, respectively. It is concluded that effective weed control in maize can be achieved through the application of either atrazine 750 g/ha as PE *fb* tembotrione 125 g/ha as PoE at 20 DAS or atrazine 750 g/ha as PE *fb* topramezone 25 g/ha as PoE at 20 DAS.

Maize productivity as affected by different crop establishment methods and weed control options in maize-wheat cropping system

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Due to continuous build-up of population of the country it is very difficult to produce enough food to feed future generation as the natural resources like land, water and labour are limited. To meet the need of even present-day population, we need to produce more food per unit resources by reducing the losses of yield due to various means like insect pests, diseases and weed infestations. The crop yield losses occurring due to weed infestations are relatively higher as compared to the losses due to insect pests and diseases. Rice-wheat cropping system covered the large portion of the land in Indo-gigantic plain. Due to continuous following of the same cropping system, arose many problems, because rice is very high-water guzzler crop. So there is urgent need of hour to shift the cropping pattern from rice-wheat to any other alternative which utilize less resources and leads to sustainable yield. Therefore, keeping in view the above situation an experiment was planned and conducted to study the productivity ofMaize (*Zea mays*) as affected by different crop establishment methods and weed control options, at research farm, Division of Agronomy, ICAR-IARI, New Delhi during 2021-2022. The experiment was laid out in split plot design consisting of three main plots and five subplots replicated thrice. The main plots consisting of three crop establishment methods as M_1: raised bed, M_2: zero tillage and M_3: conventional tillage along with straw mulch applied 3 tons/ha and the subplots consists of 5 herbicidal treatments as T_1: pyroxasulfone 0.15 kg/ha pre-emergence application (PE), T_2: pyroxasulfone 0.15 kg/ha PE followed by (*fb*) tembotrione 0.10 kg/ha pre-emergence application (PoE), T_3: atrazine PE 1 kg/ha *fb* tembotrione 0.10 kg/ha PoE, T_4: weedy check and T_5: weed free check. Amongst different crop establishment methods, raised bed recorded higher growth attributes and yield attributes compared with the other two crop establishment methods. The zero tillage and conventional tillage recorded almost similar results which are statistically on par, due to first year of experimentation. Significantly higher growth parameters (*i.e.* plant height, dry matter production, leaf area and others), yield attributes (*i.e.* cob length, cob weight, grain number per cob and others) and yield (biological yield and grain yield) was recorded in weed free plot which is on par with pyroxasulfone 0.15 kg/ha PE *fb* tembotrione 0.10 kg/ha PoE treatment and this was further followed by atrazine 1 kg/ha PE *fb* tembotrione 0.10 kg/ha PoE.

Effect of integrated weed management on winter season maize

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A field experiment was conducted during *rabi*-2017, 2018 and 2019 at Instructional farm, N. M College of Agriculture, N. A. U., Navsari, Gujarat. The study consisted of ten treatments, *viz.*, weed free, weedy check, hand weeding (HW) twice and interculturing (IC) twice at 20 & 40 days after seeding (DAS), atrazine 1.0 kg/ha as pre-emergence application (PE) followed by (*fb*) HW and IC at 40 DAS, atrazine 1 kg/ha PE *fb* intercuturingat 40 DAS, atrazine0.1 kg/ha PE + 2, 4-D amine 0.5 kg/ha post-emergence application (PoE) at 40 DAS, atrazine 1 kg/ha PE *fb* halosufuron methy 65 g/ha 0.5 kg/ha PoE at 40 DAS, atrazine1 kg/ha PE *fb* halosufuron methy 130 g/ha 0.5 kg/ha PoE at 40 DAS were tested in randomized block design with three replications. The highest weed control efficiency (95.88%) and lower weed index (1.27%) was recorded with hand weeding twice and intercuturing twice at 20 and 40 DAS followed by atrazine 1 kg/ha PE *fb* interculturing at 40 DAS) *i.e.* 91.55%. The number of cobs per plant was found non significant due to different treatments of weed management. Weed free recorded significantly higher values of length of cob with husk (30.30 cm), length of cob without husk (15.06 cm), cob girth with husk (18.91 cm), cob girth without husk (16.14 cm), row lines per cob (15.07), weight of cob with husk (130.49 g), weight of cob without husk (112.18g), number of grains per cob (508), 100 seed weight (28.84 g) and it was at par with hand weeding and two intercuturing at 20 and 40 DAS and the treatment Atrazine 1 kg/ha PE + interculturing at 40 DAS. Two hand weeding twice and interculturing twice at 20 & 40 DAS produced higher yields (4.96t/ha) along with higher net monetary returns (₹ 48035/ ha). Atrazine 1.0 kg/ha PE and interculturing at 40 DAS was next best treatment that reduced weed competition and caused better crop growth and produced higher crop yields (4.79 t/ha) along with highest net monetary returns (₹ 50049/ ha).

Influence of sustainable weed management practices on growth and yield of maize

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Field experiment on organic weed management in maize (*Zea mays* L.) was conducted to find out the most sustainable weed management practices in maize during *Rabi*, 2021-22 at Wetland Farm of S.V. Agricultural College, Tirupati, Andhra Pradesh, India. The experiment was laid out in a randomized block design with ten organic weed management practices and three replications. The treatments comprised of hand weeding twice at 15 and 30 days after seeding (DAS), groundnut shells mulch 12.5 t/ha, saw dust mulch 5 t/ha, mango leaves mulch 5 t/ha, live mulching with 2 rows of cowpea, live mulching with 2 rows of sunhemp, eucalyptus leaf extract spray 15 l/ha at 15 and 30 DAS, sunflower extract spray 18 l/ha at 15 and 30 DAS, corn gluten meal 3.5 t/ha as pre-emergence application (PE) followed by (*fb*) *hand weeding (*HW) at 30 DAS and weedy check. Maize hybrid 'DHM-117' was used. Among all the organic weed management practices, significantly higher growth parameters, *viz.* plant height, leaf area index and dry matter production, yield attributes, *viz.* cob length, number of kernels/cob and kernel weight/cob and yield were recorded with corn gluten meal 3.5 t/ha as PE *fb* HW at 30 DAS. The next best treatment was hand weeding twice at 15 and 30 DAS, however it was at par with groundnut shells mulch 12.5 t/ha and mango leaves mulch 5 t/ha. Mango leaves mulch 5 t/ha resulted in higher net returns, which was at par with hand weeding twice at 15 and 30 DAS and groundnut shells mulch 12.5 t/ha. It is concluded that mango leaves mulch 5 t/ha or groundnut shells mulch 12.5 t/ha were found to be the most effective for sustainable and economical weed management in maize under organic farming.

Weed management approaches for rice–wheat system

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Rice-wheat (RW) cropping system is the world's largest agricultural production system, which is of immense importance for food security, employment, income and livelihood. Weeds are the major problem in improving crop production by farmers, and weeds threaten the crop productivity globally. The weeds alone cause crop production loss up to 37%. Moreover, weed management is one of the costliest operations in crop production. Due to changing climatic condition, shift in weed flora has occurred. In addition, inappropriate agriculture practices such as excessive tillage, repeated use of herbicides of same group, inaccurate dose and timing of herbicide application have amplified the complexity of the situation. In current farming situation, manual weeding is increasingly becoming difficult task due to labour shortage at the peak period and higher wages. Weed control using herbicides, even though easy, effective and economical, its timing and application dosage rate are very crucial without which it may result in development of herbicide resistant weeds and adversely affect the management of weeds. Thus, viable and potential alternative options for effective management of weeds need to be developed. Practicing need-based conservation agriculture (CA) practices such as minimum tillage, sensible crop diversification, appropriate surface residue retention along with the use of pure quality seed (without seed admixture), stale seed bed technique and rational use of herbicides are potential tools for efficient weed management in R-W system for minimising the weed infestation as well as climate mitigation, improving resource use efficiency, soil health and environment quality. Research conducted at BHU, Varanasi indicated that complete conservation agricultural based practices *i.e.* zero till (ZT) direct-seeded rice- ZT wheat- ZT greengram + along with residue retention helped in minimising the weed infestation, particularly seasonal annual weeds as compared to conventional establishment system. Further, suitable weed management techniques with CA based establishment system significantly reduced weed density.Hence, efforts should be more focused to generate viable CA based practices along with appropriate weed management measures including new herbicide molecules and their rotation to address the issues of weed resistance, resource degradation and climate change.

Enhancement of productivity and profitability of wheat with integrated weed management

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Field experiment was conducted during *Rabi* season of 2016-17 and 2017-18 at Agricultural Research Station, Dharwad, Karnataka, India to evaluate the effect of pre-emergent herbicides on weed control and productivity and profitability in irrigated wheat.The pooled data of two years revealed that the pre-emergence application (PE) of pendimethalin (525 g/ha) followed by (*fb*) hand weeding at 20-25 days after seeding (DAS) recorded significantly higher grain yield (42.3q/ha) than other weed control treatments and found on par with sulfosulfuron 15g/ha *fb* hand weeding at 20-25 DAS (40.7q/ha) and pendimethalin 1kg/ha PE *fb* hand weeding at 20-25 DAS (38.7 q/ha). The biomass yield (121.38 q/ha), higher number of grains/earhead (42.87) were also significantly higher with pendimethalin 525 g/ha PE *fb* hand weeding at 20-25 DAS than other weed control treatments and found on par with sulfosulfuron 15g/ha *fb* hand weeding at 20-25 DAS (120.30q/ha) and one intercultivation and hand weeding. The differences in earhead/ m^2 and 1000 seed weight were non significant amongst different treatments. The lower weed density and biomass were recorded with pendimethalin *fb* hand weeding at 20-25 DAS than other weed control treatments followed by sulfosulfuron 15g/ha *fb* hand weeding at 20-25 DAS. The higher weed control efficiency (70.98%) was recorded with pendimethalin 525 g/ha) followed by sulfosulfuron 15g/ha and pendimethalin 1kg/ha. The higher gross returns, net returns and benefit : cost ratio was obtained with Pendimethalin 525 g/ha + *fb* hand weeding at 20-25 DAS over other weed control treatments and found on par with sulfosulfuron 15g/ha + *fb* hand weeding at 20-25 DAS.

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Residual herbicidal effect of diuron on succeeding chickpea in maize–chickpea sequence cropping

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Maize (*Zea mays* L.) is one of the major cereal crops with an area of 9.2 mha with the production of 27.8 mt at an average productivity of 2.96 t/ha in the country. In Karnataka, it occupies an area of 1.38 mha with the production of 4.4 mt and an average productivity is 4.4 t/ha. Chickpea is the important *Rabi* pulse grown after maize and the area under maize – chickpea sequence is substantial. Though maize is widely spaced fast growing crop; farmers are using herbicides for the weed control due to paucity of labours. Some of the herbicides have shown toxicity on the succeeding crops. In this experiment the objective was to see the residual effect of diuron on the succeeding crop. A field experiment was conducted during *Kharif* season 2014 and 2015 at Main Agricultural Research Station, College of Agriculture, Dharwad, Karnataka. Nine treatments with three replications were laid out in randomized complete block design. All the recommended package for maize and chickpea were followed. In the experimental plots diverse weed species were observed. Some of them were: *Cyperus rotundus*, *Cyanodon dactylon*, *Euphorbia hirta*, *Euphorbia geniculata*, *Cynotis* sp. *Physalis minima*, *Sonchus* sp., *Phyllanths niruri, Commelina benghalensis, Dinebra retroflexa, Digera arvensis* and *Eleusine* sp. Grain yield of maize was significantly influenced by diuron at different doses. Diuron 800 g/ha old formulation (OF) recorded 6.79 t/ha of grain yield and was on par with the weed free check (7.68 t/ha); diuron 1600 g/ha-new formulation (NF) (7.13 t/ha) and atrazine 1000 g/ha (6.52 t/ha). Irrespective of the dose and type of formulation either old or new all the diuron herbicide applications recorded significantly higher maize grain yield over metsulfuron-methyl 6 g/ha (3.07 q/ha) and un weeded control (6.09 t/ha). Extent of reduction in maize grain yield was least in diuron 1600 g/ha-NF (7.12%) over weed free check. The higher and comparable yield in diuron treated plots was due to lesser herbicide toxicity on maize (1.33), lesser weed biomass (432 kg/ha) and better weed control efficiency (58.6%) at 60 DAS. Diuron 800 g/ha can be effectively used as an alternative herbicide in maize as the grain yield obtained in different diuron doses was on par with weed free check. The residual effect of diuron was not evident in the succeeding chickpea grain yield in both the years. In the first year the chickpea yield ranged from 0.266 to 0.339 t/ha while in the second year it was 0.642 to 0.931 t/ha. This was probably due to very low weed incidence as the crop was raised under rainfed condition under minimum tillage condition. In general, the weed intensity was low in *Rabi* season coupled with rainfed and minimum tillage condition. The herbicide rates did not show any adverse residual effect on the chickpea emergence and dry weight per plant.

Effect of 2,4-D Sodium salt 80% WP on weeds, productivity and economics of *Rabi* hybrid maize

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Maize is a very popular crop in *Rabi* season in the eastern parts of Uttar Pradesh in India but it is very prone and much sensitive to infestation of broad-leaved weeds. Maize has high nutrient content, amino acids and many value-added products in national and international market but the quality and production may reduce due to weeds which results in poor production and productivity in Varanasi. To overcome this major problem in this valuable and multipurpose crop an experiment was conducted. Hybrid maize was sown at AICRP Maize, Agricultural Research Farm BHU Varanasi with 8 treatments and 3 replications in randomized block design in *Rabi* season of the year of 2021. Maize hybrid DHM - 121 was sown at the seed rate of 25 kg/ha in 60 × 20 cm^2 spacing. Treatments tested in the experiment were: T_1- weedy check, T_2- hand weeding twice at 20 and 40 days after seeding (DAS), T_3- pre-emergence application (PE) of atrazine 1000 g/ha, T_4- post-emergence application (PoE) of 2, 4-D sodium salt 1000 g/ha (market standard), T_5-2, 4-D sodium salt 750 g/ha PoE, T_6-2, 4-D sodium salt 1000 g/ha PoE, T_7- 2, 4-D sodium salt 1250 g/ha PoE and T_8- weed free. PoE herbicides were sprayed with flat fan nozzle fitted knapsack sprayer with the water volume of 500 litres per hectare at 25 DAS. The objectives of the experiment were to findout the best weed control treatment for getting higher grain yield and monetary returns. The field was infested with major broad-leaved weeds (*Physalis minima, Chenopodium album and Parthenium hysterophorus*), sedge (*Cyperus rotundus*) and grasses (*Cynodon dactylon*, *Polypogon monspeliensis*) in hybrid maize. At 60 DAS, the lower broad-leaved weed density and biomass were observed in 2, 4-D Sodium salt 1250 g/ha PoE as compared to 2, 4-D sodium salt 750 g/ha PoE, 2, 4-D sodium salt 1000 g/ha PoE, 2, 4-D sodium salt 1000 g/ha PoE (market standard) with higher weed control efficiency and lower weed index. However, 2, 4-D sodium salt 1250 g/ha PoE improved plant height, dry matter accumulation, leaf area index and chlorophyll content of maize due to reduced weed growth and crop weed competion as compared to 2, 4-D sodium salt 750 g/ha PoE, 2, 4-D sodium salt 1000 g/ha PoE and 2, 4-D sodium salt 1000 g/ha PoE (market standard). 2, 4-D sodium salt 1250 g/ha PoE had more grain and stover yields with higher gross returns and B:C ratio in comparison to 2, 4-D sodium salt 750 g/ha PoE, 2, 4-D sodium salt 1000 g/ha PoE and 2, 4-D sodium salt 1000 g/ha PoE (market standard).

Chemical weed management practices on growth and yield of sweet corn

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An experiment was conducted during *Kharif* 2019 at College of Agriculture, Dhule. Experiment consisted of ten treatments laid out in randomized block design with three replications. Different weed control treatments had significantly influenced the weed population, growth and yield of sweet corn. All the growth parameters of sweet corn, *viz.*, plant height, number of leaves and total dry matter accumulation per plant, were significantly higher in weed free check. Among the chemical weed management treatments, pre-emergence application (PE) of pendimethalin 1000 g/ha followed by (*fb*) post-emergence application (PoE) of tembotrione 120 g/ha 30 DAS recorded significantly higher growth parameters and it was par with pendimethalin 1000 g/ha PE *fb* 2,4- D dimethyl amine 1000 g/ha PoE.The significant effect on sweet corn plant growth character was noticed due to different treatments which resulted in enhanced yield contributing character, *viz.*, number of cob per plan, length of cob with husk (cm), weight of cob with husk (g), diameter of cob with husk (cm), weight of grain per cob (g), number of grains per cob and number of grain rows per cob. The highest green cob and fodder yield of sweet corn (15.8 and 32.4 t/ ha, respectively) were with weed free and among herbicidal treatments, higher green cob and fodder yield was observed with pendimethalin 1000 g/ha PE *fb* tembotrione 120 g/ha PoE 30 DAS (14.8 and 30.7 t/ ha, respectively) and it was at par with pendimethalin 1000 g/ha PE *fb* 2,4-D dimethyl-amine 1000 g/ha/ ha PoE (14.0 and 29.5 t/ ha, respectively). This may be attributed to the significant reduction in weed density and biomass, which lead to reduction in crop-weed competition. The elimination of weeds during early crop growth stages resulted in better plant growth and yield. Among the chemical weed management treatments, pendimethalin 1000 g/ha PE *fb* tembotrione 120 g/ha PoE 30 DAS recorded higher gross and net monetary return. Benefit cost ratio was maximum in sequential application of pendimethalin 1000 g/ha PE *fb* 2, 4-D dimethyl-amine 1000 g/ha PoE (2.97) followed by pendimethalin 1000 g/ha PE *fb* tembotrione 120 g/ha PoE 30 DAS (2.92). However, the gross and net monetary returns were maximum with weed free check whose B: C ratio was less as compared to sequential application of pendimethalin 1000 g/ha PE *fb* 2, 4-D dimethyl amine 1000 g/ha PoE and pendimethalin 1000 g/ ha PE *fb* tembotrione 120 g/ ha PoE30 DAS) due to higher cost for labor for weeding in weed free.

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Effect of different herbicides on growth and yield of wheat

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Wheat is an important staple diet for millions of people in India, mainly in the northern and north-western parts of the country. In India, wheat is mainly cultivated in North Western Plain Zone (NWPZ) covering the states like Punjab and Haryana. However, it is also a popular choice in *Rabi* season among the farmers of North Eastern Plain Zone (NEPZ) covering West Bengal, Bihar, Jharkhand, Assam and parts of Uttar Pradesh. Weeds are an important biotic constraint and the conservative estimate of about 10% loss amounts to a total loss of about 25 mt of food grains resulted in at approximately ₹ 65000 crores (USD 13 billion) in present context. On an average, weeds deplete 30-40 kg N,10-15 kg P_2O_5 and 20-40 kg K_2O per hectare. Depending upon nature of weed flora and degree of infestation, yield losses up to 15-30% occur in wheat. Critical period of crop-weed competition in wheat was estimated between 25–57 days after sowing (DAS). Higher net returns and benefit cost ratio can be realized keeping the crop weed-free for first 60 DAS. Among various weed control methods, mechanical and cultural methods of weed control sometimes are not effective. Use of herbicides is much more economical than mechanical/manual methods. Indiscriminate and unscientific use of herbicides may cause environmental hazards. Thus, this experiment was planned with an objective to identify effective weed management treatments in wheat. The experiment was laid out in a Randomized Block Design (RBD) with 3 replicates. Eight treatments include: pre-emergence application (PE) and, early post-emergence application (EPoE) of herbicides applied in sequence and EPoE followed by (*fb*) post-emergence application (PoE) of herbicides in sequence were evaluated with weed-free and weedy check. The Wheat variety used in the experiment was *DBW 187*.The experiment was conducted during *Rabi,* 2021-22. The weeds that occurred in the experimental plots, include: *Cynodon dactylon, Chenopodium album, Polygonum persicaria, Polygonum pensylvanicum, Polygonum oriantale, Polygonum hydropipper, Physalis minima and Solanum nigrum.* Weed-free recorded significantly higher yield (4.85 t/ha) which was statistically at par with Clodinafop-propargyl EPoE *fb* carfentrazone-ethyl (4.52 t/ha) PoE. Weedy check registered lowest grain yield (2.45 t/ha). Among the herbicidal treatments, Clodinafop- propargyl EPoE *fb* Carfentrazone-ethyl PoE recorded significantly lesser weed density and biomass, higher weed control efficiency (84.08% at 60 DAS and 81.31% at 90 DAS), higher weed control index (82.20% at 60 DAS and 81.96% at 90 DAS), higher herbicide efficiency index (84.48%) with lower weed index (6.80%) values. All the herbicide treated plots exhibited higher B:C than the weedy check. The maximum B:C (1.86) was observed in clodinafop-propargyl EPoE *fb* carfentrazone-ethyl PoE. Weed-free condition showed the best result in all aspects, however, the cost involved was higher (B:C 1.74). Therefore, combination of EPoE Clodinafop-propargyl PE*fb* PoE carfentrazone-ethyl can be recommended for effective control of weeds in wheat of *terai* region of West Bengal.

Nutrient uptake by weed and wheat as influenced by different weed management practices

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A field experiment was conducted at the Agronomy research farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Rabi* season of 2020-21, to study the effect of different weed management practices on nutrient uptake by wheat crop and weeds. The treatments comprised of six chemical weed management practices T_1: post-emergence application (PoE) of prosulfocarb 80 EC @ 1600 ml. *a.i./ha*, T_2: prosulfocarb 80 EC @ 2000 ml. *a.i./ha* PoE, T_3: prosulfocarb 80 EC @ 3000 ml. *a.i.* ha^{-1} PoE, T_4: sulfosulfuron 25g. /ha PoE, T_5: clodinopop + metsulfuron 60 + 4g. */ ha* PoE, T_6: sulfosulfuron + metsulfuron 30 + 2g*./ha* PoE and three non-chemical treatments: T_7: weed free up to 60 days after seeding (DAS), T_8: weedy check and T_9: hand weeding twice at 20 and 40 DAS. They were tested in randomized block design and replicated three times. The nutrient contents of weeds and wheat seed and straw were quantified by adopting the standard procedures. The results revealed that maintenance of wheat as weed free up to 60 DAS followed by hand weeding twice and mixture of sulfosulfuron + metsulfuron 30 + 2g. */ha* recorded the highest content of nutrients, *viz.*, nitrogen (N), phosphorus (P) and potassium (K) in wheat grain and straw and recorded the highest content of N, P and K in grain and straw. The weedy check recorded the lowest amount of N, P and K content in wheat grain and straw with maximum amount of N, P and K uptake by weeds. The lowest amount of N, P and K uptake by weeds was registered with weed free up to 60 DAS followed by hand weeding twice and herbicide mixture of sulfosulfuron + metsulfuron 30 + 2 g/ha.

Chemical weed management in maize and its residual effect of herbicides on succeeding mustard

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A field experiment was conducted at Advanced Centre for Rainfed Agriculture, Rakh Dhiansar of Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu during the crop growing seasons of 2016-2017 and 2017-2018 to identify the best herbicide option for weed management in maize (*Zea mays* L.) The experiment was laid out in randomized block design with 3 replications. The treatments consisting of different combinations of tembotrione, halosulfuron, atrazine, 2, 4-D and mertibuzine as sequential or tank mix along with weed free and weedy check for comparision. The soil of the experiment was sandy loam in texture and slightly acidic in reaction, low in organic carbon and available nitrogen but medium in available phosphorus and potassium. The experimental field was infested heavily with different categories of weeds. The major weed flora observed in maize crop experimental field were: *Digiteria sanguinalis, Acrachne racemosa, Eragrostis tenella, Physalis minima, Phyllanthus nururi, Solanum nigrum, Cynodon dactylon, Amaranthus viridis, Echinochloa colonum, Eleusine aegyptium, Digitaria sanguinalis, Cyperus rotundus, Cyperus iria* during both the years of experimentation. Tembotrione 100 g/ ha + atrazine 750 g/ha at 15 days after seeding (DAS) reduced the total weed density, weeds biomass and weed index and increased the weed control efficiency, maize grain and stover yields which was at par with tank mix application of tembotrione 100 g/ha +atrazine 500 g/ha at 15-20 DAS,tembotrione 100 g/ ha + halosulfuron 67.5 g/ha at 15-20 DAS,tembotrione 100 g/ha + halosulfuron 52.5 g/ha at 15 DAS, and atrazine 1000 g/ha 0-3 DAS *fb* tembotrione 100g/ha 15-20 DAS during both years. Highest B: C ratio of 3.11 was obtained with tembotrione 100 g/ha + atrazine 500 g/ha at 15-20 DAS followed by the treatment of tembotrione 100 g/ha + atrazine 750 g/ha at 15-20 DAS. Different weed management treatments applied in maize had no residual toxicity effect on mustard growth parameters, yield attributes, yield and soil fertility status during both the years.

TECHNICAL SESSION 3

Weed management in oilseeds and vegetable crops

Effect of herbicides on soil microflora of soybean on vertisol soil under south eastern Rajasthan

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Soybean [*Glycine max* (L) Merrill] has emerged as a potential protein as well as oilseed crop worldwide. It is widely grown in Rajasthan, Maharashtra and Madhya Pradesh due to its wider adaptability and high yield potential as compared to any other oilseed and pulse crop in the *Kharif* season. In the recent past, India has made an impressive progress in achieving self sufficiency to agricultural production by enhancing the productivity of several crops. However, despite of concentrated efforts being made to increase production of oilseeds, it has not brought any perceptible change in their per capita availability to predominantly vegetarian population of our country. The experiment was carried out in soybean crop during *Kharif* 2021 at Agricultural Research Station, Ummedganj-Kota, Agriculture University, Kota with randomized block design (RBD) with sixteen treatments and three repetitions. Application of pre-emergence herbicides *i.e.* pendimethalin 1.0 kg/ha and pendimethalin + imazethapyr 960 g/ha was done just after sowing of soybean. Whereas, all the post-emergence herbicides *i.e.* imazethapyr 100 g/ha, fluthiacet-methyl 12.5 g/ha, clodinafop propargyl 60 g/ha, fomesafen 250 g/ha, fluazifop-p-butyl 250 g/ha, propaquizafop 50 g/ha, propaquizafop + imazethapyr 93.75 g/ha, propaquizafop + imazethapyr 125 g/ha, sodium acifluorfen + clodinafop propargyl 183.7 g/ha, sodium acifluorfen + clodinafop propargyl 245 g/ha, fomesafen + fluazifop-p-butyl 165 g/ha and fomesafen + fluazifop-p-butyl 220 g/ha was done with the use of 0.1 per cent non-ionic surfactant at 16 days after seeding (DAS). All herbicidal weed control measures applied as pre-emergence and post-emergence did not influence total bacterial populations. Though, weedy check recorded maximum bacterial population (22.33 x 10^4 cfu/g) followed by two hand weeding at 20 & 40 DAS. All herbicidal weed control measures did not cause significant variation in total fungi population and differences were non-significant. However, maximum total fungi population was recorded under weedy check (13.67 x 10^4 cfu/g) and hand weeding twice at 20 and 40 DAS (13.00 x 10^4 cfu/g) and least under pendimethalin + imazethapyr 960 g/ha (10.00 x 10^4cfu/g). All herbicidal weed control treatments did not cause significant variation in total actinomycetes population and differences were non-significant. While, maximum total actinomycetes population was recorded under weedy check (12.33 x cfu/g) closely followed by hand weeding twice at 20 and 40 DAS (12.00 x 10^4 cfu/g). It is concluded that all applied herbicides treatments had no significant effect on soil microbial population *i.e.* total bacterial, fungi, actinomycetes populations.

Efficacy of ethalfluralin against weeds in soybean grown in Rajasthan

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A field experiment was carried out at Agricultural Research Station, Agriculture University, Kota during the *Kharif* 2018-19 and 2019-20 to evaluate the efficacy of ethalfluralin against weeds in soybean in randomized block design comprising eight treatments, *viz.* pre-plant incorporation (PPI) of ethalfluralin 540 g/ha; ethalfluralin 630 g/ha; ethalfluralin 720 g/ha; ethalfluralin 810 g/ha; imazethapyr 100g/ha post-emergence application (PoE);pendimethalin 1000 g/ha pre-emergence application (PE); weed free treatment and untreated control replicated four times. Weed flora was dominated by the grassy weeds *i.e. Echinochloa crusgalli*, *Echinochloa colonum* and *Cyperus rotundus* (sedges), *Digera arvensis, Celosia argentea, Commelina benghalensis and Trianthema monogyna* were among the broad-leaved weeds. All the doses of ethalfluralin effectively controlled the *Echinochloa spp* and grasses in soybean crop. The density of weeds varied 2.14-3.43, 3.89-5.32 and 3.61-5.09/m^2 during the year 2018 while it was 2.07-3.14, 3.60-5.29 and 3.59-4.99 during 2019 at 30, 60 DAA and at harvest, respectively and weed biomass varied from 11.06 to 22.16 g/m^2 during 2018 and 9.55 to19.58 g/m^2 during 2019 at 60 DAA, respectively with ethalfluralin from 540-810 g/ha. The reduction in the weed dry biomass was maximum with ethalfluralin 810 g /ha (11.06 and 9.55 g /m^2 at 60 DAA) and was at par with its lower dose ethalfluralin 720 g /ha. However, weed free treatment registered lowest values of *Echinochloa spp*. as well as dry biomass at all the stages as compared to the other treatments. The maximum grassy weeds control efficiency was recorded by weed free treatment at all the stages followed by ethalfluralin 810 g/ha in both the years. Ethalfluralin 540-810 g/ha PPI significantly increased soybean growth, yield attributes and yields. The highest soybean yield of 1.59 and 1.96 t /ha was registered under weed free, whereas seed yield varied with various ethalfluralin doses *i.e*. 540-810 g/ha and were 1.25-1.55 and 1.33-1.74 t/ha, which were significantly superior over weedy check during both the years, respectively. Among the herbicidal treatments, the highest soybean yield was recorded with ethalfluralin 810 g/ha PPI with an increase in yield of 74.0% when compared to weedy check.

Effect of weed management practices in soybean-pigeonpea intercropping system and its residual effect on succeeding crops

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In the tribal pocket of Middle Gujarat, soybean is dominant crop wherein, intercropping with pulses are remunerative for the tribal farmers. Among various factors for augmenting higher production, weed management is the key factor. Yield reduction due to weeds is much higher if timely weed control measures are not taken. Looking this, an experiment was conducted to study the effect of weed management in soybean - pigeonpea intercropping system and its residual effect on succeeding crops", during two consecutive *Kharif* season of the year 2017-18 and 2018-19 at the Agricultural Research Station, Anand Agricultural University, Derol, (Gujarat). The soil of the experimental field was loamy sand in texture having low in available organic carbon and nitrogen. Medium in phosphorous and high in potassium. The experiment was laid out in randomized block design with four replications. The ten weed control treatments were studied, *viz.* pendimethalin 1000 g/ha PE *fb* interculturing + hand weeding at 30 DAS, clomazone 1000 g/ha PE *fb* interculturing + hand weeding at 30 DAS, imazethapyr 75 g/ha PoE *fb* interculturing + hand weeding at 30 DAS, propaquizafop 75 g/ha PoE *fb* interculturing + hand weeding at 30 DAS, quizalofop ethyl 50 g/ha PoE *fb* interculturing + hand weeding at 30 DAS, fenoxaprop -p-ethyl 100 g/ha PoE *fb* interculturing + hand weeding at 30 DAS, imazamox 35% + imazethapyr 35% (pre-mix) 70 g/ha PoE *fb* interculturing (IC) + hand weeding (HW) at 30 DAS, sodium acifluoren 16.5% + clodinafop propargyl 8% EC (Pre-mix) 80+165 g/ha PoE *fb* interculturing + hand weeding at 30 DAS, interculturing + hand weeding at 20 and 40 DAS and weedy check. Result of field experiment revealed that significantly the lowest density and dry weight of weed with higher weed control efficiency were recorded under treatment IC *fb* HW at 20 and 40 DAS, imazamox 35% + imazethapyr 35% (premix) 70 g/ha PoE *fb* IC and HW at 30 DAS and imazethapyr 75 g/ha PoE *fb* IC and HW at 30 DAS. The said treatments also recorded higher growth and yield attributes, soybean equivalent yield, net returns and benefit cost ratio. None of the herbicides showed adverse effect on succeeding crops, *viz.*, maize, pearl millet and cucumber grown after harvest of soybean and pigeonpea.

Potential of weed seedbank dynamics and evaluation of some new post-emergence herbicides and their mixtures for weed control in soybean and their residual effect on wheat

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An experiment was conducted on the potential of weed seedbank dynamics and evaluation of some new post-emergence herbicides and their mixtures for weed control in soybean (*Glycine max* L.) and their residual effect on wheat (*Triticum aestivum* L.) during *Kharif* and *Rabi* seasons of 2018-19 and 2019-20. The experiment comprised of 12 treatments was laid out in randomized block design with three replications. The soybean (*cv*. GJS-3) and wheat (*cv*. GW-366) were cultivated using standard package of practices. The results revealed that next to the weed free treatment, inter cultivation (IC) and hand weeding (HW) at 15 and 30 days after seeding (DAS) (T_{10}), pendimethalin 900 g/ha as pre-emergence application (PE) followed by (*fb*) IC and HW at 30 DAS (T_1), pendimethalin 900 g/ha PE *fb* propaquizafop + imazethapyr 50 + 75 g/ha (pre-mix)_ post-emergence application (PoE) at 30 DAS (T_6) and pendimethalin 900 g/ha PE *fb* sodium acifluorfen + clodinafop-propargyl (pre-mix) 80 + 165 g/ha PoE at 30 DAS (T_9) enhanced growth parameters, *viz.*, plant height at harvest, number of root nodules/plant at 60 DAS, CGR (g/m^2/day) during 60 to harvest and RGR (g/g/day) during 60 DAS to harvest and higher seed (kg/ha) and stover yield (kg/ha). Next to the weed free check (T_{11}), significantly the lowest dry biomass of total weeds (Monocot, dicot and sedge), lower weed index (WI) and higher weed control efficiency (WCE) of total weeds was recorded with T_{10}, T_1, T_6 and T_9. The lowest number of weed seeds (65 weed seeds /core sample) was found with the weed free check (T_{11}), which was statistically at par with the T_{10}, T_1 and T_6. On an average, higher seedbank depletion was observed with the weed free check (T_{11}) with depletion of 137 (66.99%), 127 (67.20%) and 132 (69.09%) weed seeds/core, T_{10} depleted 130 (63.41%), 119 (62.79%) and 124 (63.11%) weed seeds /core, T_1 depleted 123 (60.16%), 110 (58.02%) and 117 (59.14%) weed seeds/ core, T_6 depleted 117 (57.07%), 105 (55.56%) and 111 (56.35%) weed seeds/ core and T_9 depleted 109 (53.17%), 100 (53.09%) and 105 (53.13%) weed seeds/ core. The carry over effect of different herbicides applied in soybean crop was found non-significant based on observations like, initial plant population, plant height, dry matter per plant, SPAD meter values, total tillers per m row length, effective tillers per m row length, number of spikelets per spike, number of grains per spike, 1000-grain weight, grain yield and straw yield of succeeding wheat crop. It can be concluded that effective control of complex weed flora with profitable production of soybean can be obtained by pendimethalin 900 g/ha PE *fb* propaquizafop + imazethapyr 50 + 75 g/ha (pre-mix) PoE at 30 DAS or pendimethalin 900 g/ha PE *fb* sodium acifluorfen + clodinafop-propargyl 80 + 165 g/ha PoE at 30 DAS. Alternatively, pendimethalin 900 g/ha PE *fb* either IC and HW at 30 DAS or IC and HW at 15 and 30 DAS can be employed according to availability of labourers without any residual effect on succeeding wheat crop under medium black calcareous clayey soil of south Saurashtra agro-climatic zone.

Evaluation of herbicides along with bio-stimulant on weed occurrence and economics of soybean under vertisols of Chhattisgarh

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A field experiment was conducted to study the effect of weed management on soybean production and economics during the *Kharif* season of 2019-20 in ‘Vertisols’ at research farm of IGKV, Raipur, Chhattisgarh. Soybean variety ‘JS 97-52’ was raised with row and plant spacing of 30×10 cm and seed rate of 75 kg/ha. A Randomized Block Design with 7 treatments and 3 replications was used. Treatments compreised of: sodium-acifluorfen (16.50%) + clodinafop-propargyl (8% EC) 1 kg/ha + Macarena 625 ml/ha (T1), imazethapyr 10 SL 1000 ml/ha + Macarena 625 ml/ha (T2), fluazifop-p-butyl (13.4% EC) 2000 ml/ha + Macarena 625 ml/ha (T3), propaquizafop (2.5% EC) + imazethapyr (3.7% ME) 2000 ml/ha + Macarena 625 ml/ha (T4), Macarena 625 ml/ha (T5), two hand weedings at 20 and 40 DAS (T6) and weedy check (T7). Macarena is a bio-stimulant and it increases the metabolism of the plant and supplements plant with glycine and antioxidants of natural origin. This bio-stimulant relieves abiotic stress and in turn increases the soybean yield. *Echinochloa colona*, *Cyperus rotundus*, *Parthenium hysterophorus*, *Digera arvensis*, *Celosia argentea*, and *Alternanthera* spp. and some other weeds were dominant in the experimental field throughout the crop growth period. Under, hand weeding twice at 20 and 40 days after seeding (DAS) (T6) followed by (*fb*) sodium-acifluorfen (16.5%) + clodinafop-propargyl (8% EC) 1000 ml/ha + Macarena 625 ml/ha (T1) recorded minimum weed density and biomass whereas maximum was observed in weedy check (T7). Weed control efficiency was highest with hand weeding twice at 20 and 40 DAS (T6) and lowest in weedy check (T7). In terms of economics, maximum gross return (₹ 88195 /ha), net return (₹ 71410 /ha) with B: C ratio (5.2) were with sodium-acifluorfen (16.5%) + clodinafop-propargyl (8% EC) 1000 ml/ha + Macarena 625 ml/ha (T1) which was followed by propaquizafop (2.5% EC) + imazethapyr (3.7% ME) 2000 ml/ha + Macarena 625 ml/ha (T4) and hand weeding twice at 20 and 40 DAS (T6). It can be concluded that hand weeding twice at 20 and 40 DAS (T6) is most suitable for the minimization of total and species wise weed density, weed biomass and weed control efficiency. Amongst herbicide-based treatments, integration of sodium-acifluorfen (16.5%) + clodinafop-propargyl (8% EC) 1000 ml/ha + Macarena 625 ml/ha (T1) recorded maximum yield as well as economic returns.

Efficacy of various herbicides to manage weeds in soybean

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Soybean is a crop of global importance and is well known for its nutrient rich plant protein with all nine essential amino acids that are lacking in other cereal crops. Soybean is most preferred crop for cultivation in Maharashtra. The sowing time for cultivation of the soybean in rainy (*kharif*) season is very short and hence it is prioritized by the farmers to take up sowing the crop rather than the use of pre-emergence herbicides for weed control. However, the losses due to weeds have been one of the major limiting factors in soybean crop production. Weed infestation in the crop is higher because of its higher row spacing, slow crop growth at early stages and warmer season due to which weeds compete with the soybean crop for water, light, space and nutrients and adversely affecting the total yield. Therefore, managing the weeds is of utmost importance. Herbicides use plays a pivotal role in weed management due to labour non availability, shortage and higher labour cost. Hence, the search of new herbicides is highly necessary. With this background, a field experiment was carried out during *Kharif* of 2018-19 at Agronomy Farm, College of Agriculture, Nagpur to study the efficiency of different herbicides on weed control in soybean. The experiment was laid out in randomized block design with eleven treatments and three replications. All the treatments were significantly superior over weedy check with all the weed parameters (total weed density, weed biomass, weed control efficiency and weed index), soybean yield parameters (no. of pods plant^{-1}, seed weight plant^{-1} and test weight) and yield (seed yield and straw yield). The lowest weed density, weed biomass, maximum weed control efficiency and lowest weed index were recorded with weed free which was followed by the treatment with one hoeing + one weeding + imazethapyr + imazemox 70 g / ha which also recorded the higher seed yield (21.00 q/ha), straw yield (34.00 q/ha) and B:C ratio (2.48) and was significantly superior over the other treatments.

Major weeds of soybean and their management in Kota region of Rajasthan

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Rajasthan is the third largest Soyabean producing state after Madhya Pradesh and Maharashtra. Kota is situated in the south-eastern part of Rajasthan and comes under Agro climatic zone V which is the main Soyabean producing area in Rajasthan. Being a rainy season crop, soybean faces severe weed competition during early stages of crop growth, resulting in severe loss of potential yield, depending on the weed intensity, nature, environmental condition and duration of weed competition. If weeds are not controlled during critical period of crop-weed competition, a reduction in the yields of soybean up to 58-85 per cent occurs, depending upon the types and intensity of weeds. Thus, it is important to keep the crop free from weeds as far as possible so as to get higher yield from soybean. Manual weeding is the best option for weed control but it is costly, time consuming and difficult due to intermittent rains. Timely unavailability of adequate labourers also possesses serious problem. Thus, herbicidal weed control remains only the choice under such situation to minimize the weed menace economically. An experiment was conducted during *kharif*, 2019 at Agricultural Research Station, Ummedganj, Kota. The dominating weed flora in the experimental field consisted of: *Cynodon dactylon* L., *Eleusine indica* L., *Echinochloa crusgalli* and *Echinochloa colona* among grassy weeds, *Boerhaavia diffusa* L., *Convolvulus arvensis* L., *Commelina benghalensis* L., *Digera arvensis* Forsk., *Celosia argentea* L. among broad-leaved weeds and *Cyperus rotundus* L., the sedge. Relative density of weeds was 49% for grassy weeds, 39% for broad leaf weeds and 12% for sedges. Hand weeding twice at 20 and 40 days after seeding (DAS) gave significantly higher soybean seed yield and net returns than herbicide-based treatments. Amongst herbicides, sodium acifluorfen + clodinafop propargyl (premix) 165 + 80 g/ha or imazethapyr + propaquizafop (premix) 50 + 75 g/ha resulted in significantly higher seed yield and net returns than other herbicides and herbicide mixtures. Therefore, under ample availability of man power, weed control in soybean should be done using manual weeding at 20 and 40 DAS while under scarcity of labour, sodium acifluorfen + clodinafop-propargyl (premix) 165 + 80 g/ha and imazethapyr + propaquizafop (premix) 50 + 75 g/ha may be used for higher soybean yield and net returns.

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Weed dynamics, yield and economics of soybean as affected by integrated nutrient and weed management practices

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A field experiment was carried out during the *Kharif* seasons of 2017 and 2018 at the research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, India to study the effect of integrated nutrient and weed management treatments on weed dynamics, yield and economics of soybean under split plot design with three replications. There were 13 dominant weed species observed in the field, *viz. Cynodon dactylon* L., *Digitaria sanguinalis* L., *Eleusine indica* L., *Bulbostylis barbata* (Rottb.) C.B. Clarke, *Cyperus iria* L., *Cyperus kyllingia* L., *Cyperus rotundus* L., *Ageratum conyzoides* L., *Amaranthus viridis* Hook. F., *Borreria latifolia* (Aubl.) K. Schum., *Cleome rutidopsperma* DC., *Mimosa pudica* L. and *Mollugo pentaphylla* L. The highest weed density at 60 DAS was recorded in N_3 (50% RDF + 50% organic through *Rhizobium* + PSB). Highest WCE at 60 DAS was recorded in N_3 (50% RDF + 50% organic through *Rhizobium* + PSB) treatment. All the weed species at 60 DAS were effectively controlled under hand weeding at 15, 30 and 45 DAS treatment where it recorded the lowest weed density and weed biomass and highest WCE followed by application of treatment of post-emergence application of propaquizafop at 0.075 kg/ha*fb* hand weeding at 45 DAS and treatment of pre-emergence application of pendimethalin at 1 kg/ha *fb* hand weeding at 30 DAS. Significantly highest grain yield (1.63 t/ha) and stover yield (2.27 t/ha) were recorded in treatment-75% RDF + 25% organic through FYM + PSB among the nutrient treatments. Among weed management treatments, hand weeding at 15, 30 and 45 DAS recorded highest seed yield and stover yield. It was followed by post-emergence application of propaquizafop (0.075 kg/ha) *fb* hand weeding at 45 DAS and pendimethalin (at 1.0 kg/ha) *fb* hand weeding at 30 DAS. Among nutrient management treatments, 75% RDF + 25% organic through FYM + PSB treatment recorded the highest cost of cultivation (₹ 46299/ha) and gross return (₹ 107736/ ha). Whereas, 50% RDF + 50% organic through *Rhizobium* + PSB treatment recorded the lowest cost of cultivation (₹ 37436/ ha). And highest net returns (₹ 62682/ ha) and B:C ratio (1.63) Among weed management treatments, hand weeding at 15, 30 and 45 DAS recorded the highest cost of cultivation (₹ 48527/ha), gross returns (₹ 136684/ha) and net return (₹ 88157/ha). However, post-emergence application of propaquizafop (0.075 kg/ha) *fb* hand weeding at 45 DAS recorded the highest B:C ratio.

Influence of weed management on productivity of soybean in northern India

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Weed infestation is taken into account a persistent and complex constraint in soybean, as it influences soybean growth and yields through competition for nutrients, water, light and space, and harms the crop through the production of allelopathic compounds. The chemical weed control measures being more convenient, time-saving, and more cost-effective, provide a weed-free condition for the early establishment of the soybean. The most effective herbicides in soybeans nowadays involve pre-plant incorporation (Trifluralin and Fluchloralin), pre-emergence (Pendimethalin, Metolachlor, Clomazone, Ethalfluralin, Diclosulam) and pPost-emergence (Imazethapyr, Fomesafen, Flyzifop-p-butyl, Quizalofop ethyl). However, use of a single herbicide leads to herbicide resistance, as evidenced in many instances. As a result, during the *Kharif* season of 2019 at N.E.B.C.R.C. of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), research work was conducted to study the effect weed management practices on yield, quality and economics of various treatments consequently applied. The soil on the experimental site was silty clay loam, neutral in pH 7.1 with high organic carbon (1.18%), medium in available nitrogen (232.7 kg/ha), phosphorus (25.8 kg/ha) and potassium (135.7 kg/ha). The experiment was laid out in a factorial randomized block design weed management practices with five levels (Pendimethalin at 1.0 kg/ha (PE), Imazethapyr at100g/ha (PoE), Pendimethalin at 1.0 kg/ha (PE) fb Imazethapyr at 100g/ha (PoE), twice hand weeding at 20 & 40 DAS and weedy check) with replicated thrice. The results showed that applying pendimethalin at 1.0 kg/ha (PE) fb imazethapyr at 100 g/ha (PoE) was the most effective treatment in reducing weed density and twice hand weeding at 20 and 40 DAS was found most effective in reducing weed dry matter accumulation as compared to other treatments. While, the highest seed yield, among weed management treatments was recorded in the twice hand weeded plots with net return (¹ .44031/ha) and B:C (2.46). Twice, hand weeding at 20 & 40 DAS was found best amongst treatments with regard to crop growth, efficiency of weed control, biochemical parameters and economic returns. However, pendimethalin at 1.0 kg/ha (PE) fb and imazethapyr at 100 g/ha (PoE) can be used as herbicidal treatments in case of the unavailability of man power.

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Effect of ethalfluralin 36% EC on growth parameters and yield of soybean

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Soybean is one of the important pulse and oilseed crop of India. It is quickly becoming the most significant oil seed crop. It is a legume crop that belongs to the leguminasae or fabaceae family and the papilionaceae subfamily. It grows in the dry-land portions of peninsular India during the *Kharif* or monsoon season (July-October). Due to the constant rains in the *Kharif* season, weed infestation will be high, and severe weed competition is one of the most major causes of soybean yield loss, estimated to be 22-77 percent. Thus, the yield is reduced and production costs increase, resulting in a decrease in farmer's income. The costly and unavailability of labours coupled with unfavourable weather conditions offer an opportunity for the chemical weed control. As a result, alternate approaches for lowering weed load during early soybean crop growth, *i.e*. the first 30-45 DAS, are required. The pre-emergent herbicides like, fluchloralin, alachlor and metachlor have been recommended for weed control in soybean and are being used by the farmers from quite long time. An attempt has been made to study the effect of pre plant herbicide along with pre-emergent herbicides on physiological parameters, growth and yield components of soybean and weed growth. Experiment was conducted at CSK HPKV, Palampur (H.P) during the *Kharif* season of 2019 and 2020 in mid hill sub-temperate sub humid agro-climatic zone [32^{o}3' N latitude, 76^{o}3' E longitude, and 1290 m altitude] to find out the effect of ethalfluralin 36% EC on growth parameters and yield of soybean. Nine weed control treatments, *viz.* ethalfluralin 540 g/ha, 630 g/ha, 720 g/ha, 810 g/ha, 1440 g/ha, imazethapyr 100 g/ha, pendimethalin 1000 g/ha, weed free treatment and weedy check were tested in Randomized Block Design with four replications. Soybean variety 'Harit soya' was sown manually in furrows 45 cm apart using a seed rate of 100 kg/ha. Recommended dose of fertilizers (20:60:40) was applied at the time of sowing. The N, P and K nutrients were applied through urea, SSP and muriate of potash, respectively. All other recommended practices were followed for raising the crop. Results revealed that ethalfluralin 810 g/ha behaving statistically alike with ethalfluralin 720 g/ha and imazethapyr 100 g/ha resulted in significantly taller plants, higher dry matter accumulation and higher seed yield. Highest absolute growth rate and crop growth rate was found with pre plant incorporation of ethalfluralin 810 g/ha.This study had shown that pre plant application of ethalflralin 810 followed by ethalfluralin 720 g/ha followed by imazethapyr 100 g/ha increased the growth and other parameters of soybean and resulted in higher seed yield as compared to other treatments.

Determining pendimethalin residues in irrigated wheat mulched with soybean residue

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The use of herbicides in wheat production continuously for a long period has detrimental effect on quality of soil. Thus, to produce good quality food, particularly in wheat it is essential to reduce the residue levels of herbicides in the agricultural soil in general. Pendimethalin is the most widely used herbicides in many crops including wheat. Pendimethalin, a dinitroaniline herbicide, is commonly used for pre-emergence control of annual grasses and broad-leaved weeds. It disrupts the mitotic sequence by inhibiting the production of microtubule protein, tubulin and inhibits cell division, cell elongation, root and shoot growth. It has been classified as less volatile herbicide which has low water solubility and high affinity for adsorption in soils. Field dissipation studies have revealed that pendimethalin is a persistent herbicide having half-life ranging from 10 to 98 days depending upon the physicochemical properties of soil, climatic conditions and agronomic practices. Field experiments were conducted at University of Agricultural Sciences (UAS), Dharwad, during *Rabi* 2020-21 and 2021-22. First factor studied was time of application i.e., pre-emergence, pre + post-emergence and post-emergence of the herbicide. Second factor was dosage of herbicide i.e., pendimethalin 1.0 kg/ha, sulfosulfuron 25 g/ha and metsulfuron- methyl 4 g/ha and pendimethalin 0.75 kg/ha, sulfosulfuron 18.75 g /ha and metsulfuron-methyl 3g/ha. The third factor was with residue (soybean 3t/ha) and without residue under minimum tillage. Samples of soil taken at harvest were analysed for pendimethalin residues by liquid chromatography tandem mass spectrometry (LC-MS/MS). The time and dosage of herbicide application significantly influenced the grasses, sedges and broad-leaved weeds in both years. The pre-emergence application of herbicide recorded lower grasses (3.04 no./m^2), sedges (1.70 no./m^2) and broad-leaved weeds (4.48 no./m^2) at 20 days after sowing (DAS) of the crop. Recommended dose of herbicide (RDH) was significantly better than 75% RDH. Application of residue did not influence the weeds. Application of 100% RDH with soybean residue with pre-emergence resultant significantly lower grasses (1.33 no./m^2), sedges (1.17 no./m^2) and broad-leaved weeds (2.39 no./m^2). More number of weed species were noticed at post-emergence application of herbicide without crop residue at 20 days. Pendimethalin applied at 75 or 100% of the recommended dose with soybean crop residue or without soybean crop residue did not show any residues in the soil (quantification level $\geq$ 0.01 mg/kg) at the time of harvest. There was no effect of dosage and crop residue on pendimethalin residue. Thus, the use of pendimethalin in wheat could be considered safe. It can be concluded that pendimethalin 1.0 kg/ha can be safely applied to the wheat crop as pre-emergence herbicide. Application of 100% RDH with soybean residue both as pre- and post-emergence resulted in significantly higher yield in both years (4.03 and 4.21 t/ha). Lower yield was obtained when wheat crop was applied with pre-emergence application of pendimethalin at 75% dosage without crop residue (2.47 and 2.61 t/ha). Weed free check recorded higher wheat grain yield in both years (4.32 and 4.33 t/ha). This was significantly on par with pre- and post-emergence application of 100% RDH + soybean residue.

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Bio-efficacy of newer ready-mix herbicides on weed dynamics, soil enzymes, microflora, nodulation activities, nutrient depletion, yield and economics of soybean and their residual effect on succeeding coriander, chickpea and wheat

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The field experiment was conducted at Research Farm of ARS, Kota during *Kharif* 2021 and *Rabi* 2021-22 to study bio-efficacy of newer ready-mix and sole herbicides for weed dynamics, soil enzymes, microflora, nodulation activities, nutrient depletion, yield and economics of soybean (cv.JS20-34) and their residual effect on succeeding coriander, chickpea and wheat crops. The soil was clay loam having pH 7.7, organic carbon 0.49% and N,P,K 210, 23.5 and 400 kg/ha,respectively. Post-emergence application (PoE) of herbicides was done at 16 days after seeding (DAS) with knapsack sprayer. The experiment consisted of 16 weed control treatments comprising ready-mix herbicides and their application alone. Most prominent grassy weeds (53.1%) were: *Echinochloa colona*, *E. crusgalli*, *Cyanodon dactylon*, *Eleusine indica*, *Cyperus rotundus* (9.4%) whereas among broad-leaved weeds (46.9%): *Celosia argentea*, *Digera arvensis*, *Commelina benghalensis* and *Trianthema portulacastrum* were dominant species. Fomesafen+fluazifop-p-butyl 220 g/ha PoE was found significantly superior in reducing all weeds density, weed biomass and nutrient depletion over rest of the treatments and resulted higher weed control efficiency (85.41, 79.97 and 77.39% at 30, 60 DAS and at harvest, respectively) closely followed by propaquizafop+imazethapyr 125 g/ha PoE and sodium acifluorfen+clodinafop-propargyl 245g/ha PoE. Among herbicides applied alone, post-emergence application of fomesafen and fluthiacet-methyl was found more effective in controlling broad-leaved weeds while clodinafop-propargyl, fluazifop-p-butyl and propaquizafop were more effective on grassy weeds. However, Pre-emergence application (PE) of pendimethalin and pendimethalin+imazethapyr were found effective in controlling weeds at initial stage only. Maximum nodules/ plant and their dry weight recorded with hand weeding twice, fomesafen + fluazifop-p-butyl 220 g/ha PoE, sodium acifluorfen+clodinafop-propargyl 245 g/ha PoE, propaquizafop+imazethapyr 125 g/ha PoE. Hand weeding registered maximum dehydrogenase enzyme activity (0.329 µgTPF/g soil/d) closely followed by herbicides mixture and sole herbicide while urease and phosphatase enzyme activities were not much influenced. Herbicidal weed control measures either PE or PoE did not influence total bacterial, fungi and actinomycetes population. Though, weedy check poses higher bacterial ($22.33x10^4$ cfu/g), fungi ($13.67x10^4$ cfu/g) and actinomycetes ($12.33x10^4$ cfu/ g) population followed by two hand weeding. Ready-mixtures were found significantly superior over pendimethalin+imazethapyr 960 g/ha PE in enhancing seed, straw and biological yield. Among herbicides, ready-mix PoE fomesafen + fluazifop-p-butyl 220 g/ha PoE (1.76, 2.36 and 4.12 t/ha), propaquizafop+imazethapyr 125 g/ha PoE (1.73, 2.32 and 4.05 t/ha) and sodium acifluorfen+clodinafop-propargyl 245 g/ha PoE (1.63, 2.20 and 3.83 t/ha) resulted in significantly higher seed, straw and biological yield, respectively. Maximum and significantly higher net return (₹ 55,008/ha) and B: C ratio (2.30) was fetched with ready-mix of fomesafen+fluazifop-p-butyl 220 g/ha PoE over the rest of the herbicidal treatments. Followed by hand weeding twice (₹ 52,988/ha), propaquizafop+imazethapyr 125 g/ha PoE (₹ 51,243/ha) and sodium acifluorfen+clodinafop-propargyl 245 g/ha PoE (₹ 49,051/ha). The ready mixture or sole herbicides (PE and PoE) applied to soybean crop had no phytotoxicity on soybean and no residual effects on succeeding coriander, chickpea and wheat crops since their growth, yield attributes and yields remain unaffected by the herbicides and were not detected.

Weed flora in soybean as influenced by weather parameters and weed management practices

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Studies on effective and practical weed management practices that can be used effectively and economically under varied weather conditions are very essential. Hence, this study was conducted with an objective to assess the efficacy and comparative performance of broad spectrum pre- and post-emergence herbicides in soybean. This study was conducted at experimental farm of Agronomy department, V.N.M.K.V., Parbhani during *Kharif* season of 2021.The experiment was laid out in split plot design with three main plot treatments comprised of three dates of sowing, *viz*. D1: 26th meteorological week (MW) (25 June to 1 July), D2: 28MW (9 July to 15 July), D3: 30MW (23 July to 29 July) while the sub plot treatments comprised of four weed management treatments, v*iz,* W_1: pre-emergence application (PE) of diclosulam 22-26 g/ha followed by (*fb*)1hoeing, W_2: post-emergence application (PoE) of sodium-acifluorfen 16.5% + Clodinafop-propargyl 8% WP 80 + 165 g/ha *fb* 1hoeing,W_3: 1 hand weeding (HW) *fb* 1 hoeing,W_4: weedy check. Sowing was done in given meteorological weeks as per treatments during *Kharif* 2021. The recommended nutrients and plant protection schedule was followed. In each experimental plot, an area of a quadrat (1 x 1 m) was fixed and observations on monocot, dicot (broad-leaved), and total weed density and weed biomass were recorded at different stages of crop growth. The lowest weed density of monocot and broad-leaved weeds was recorded with latest date of sowing while among the weed management treatments the lowest weed density of monocot and broad-leaved weeds at 30 and 45 days after sowing was recorded with 1 HW+1 hoeing and was found at par with sodium-acifluorfen 16.5% + Clodinafop-propargyl 8%WP 80+165 g/ha PoE *fb* 1hoeing in all the three different dates of sowing. The yield parameters and seed yield of soybean were highest with first date of sowing. *i.e*. sowing in 26 metereological week as compared with sowing in 28 th and 30 th metereological week. Among differentweed management practices, the seed yield was significantly higher with 1 hand weeding *fb* 1 hoeing and was found comparable with sodium-acifluorfen 16.5% + Clodinafop-propargyl 8%WP 80 + 165 g/ha PoE *fb* 1hoeing. The differences in soybean yield were wider between pre- and post-emergence herbicide treatments in first two dates of sowing as compared to the latest date of sowing, which may be due to reduced weed flora as influenced by weather parameters like rainfall distribution and temperature in delayed sowing. Thus, it can be concluded that sodium-acifluorfen 16.5% + clodinafop-propargyl 8%WP 80+165 g/ha PoE *fb* 1hoeing was found effective in controlling monocot and broad-leaved weeds in soybean as compared to other weed control practices and was comparable with 1 hand weeding *fb* 1 hoeing treatment, while these results were more significant under earlier dates of sowing as compared to delayed one.

Bio-efficacy of herbicides on weed management in groundnut under rice-groundnut system in coastal zone of Karnataka

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A field experiment was conducted to study the "bio-efficacy of herbicides on weed management in groundnut under rice-groundnut system in coastal zone of Karnataka" at Agricultural Research Station, Kumta, Uttara Kannada during *Rabi*-summer 2016-17. Nine weed control treatments including pre-emergence application (PE) of herbicides followed by hand weeding (HW) or early post-emergence application (EPoE) in sequence along with control were evaluated in randomized block design with three replications. Pendimethalin, quizalofop-p-ethyl and imazethapyr were found safe herbicides as the crop was normal and phytotoxic symptoms were not seen throughout its growth period. Among the weed management treatments, weed control efficiency was significantly higher with pendimethalin 1.5 kg/ha PE followed by (*fb*) one hand weeding at 25 DAS which was on par with pendimethalin 1.5 kg/ha PE *fb* post-emergence application (PoE) imazethapyr 75 g/ha at 20-30 DAS, at 20,40,60 DAS and at harvest. Total weed density was significantly lower with pendimethalin 1.5 kg/ha PE *fb* one hand weeding at 25 DAS. Number of pods and pod yield per plant was significantly higher with pendimethalin 1.5 kg/ha PE *fb* one hand weeding at 25 DAS which was on par with pendimethalin 1.5 kg/ha PE *fb* imazethapyr 75 g/ha PoE at 20-30 DAS. Pod yield (2.23 t/ha), kernel yield (1.29 t/ha), gross returns (₹ 92,446/ha), net returns (₹ 45,239/ha) and benefit cost ratio (1.96) were significantly higher with pendimethalin 1.5 kg/ha PE *fb* one hand weeding at 25 DAS which was on par with pendimethalin 1.5 kg/ha PE *fb* imazethapyr. 75 g/ha PoE at 20-30 DAS.

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Effect of pre- and post-emergence herbicides on weeds and yield of summer groundnut

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Among all oilseed crops, groundnut accounts for more than 40-50% in area and 60 to 70% in production in the country. Among oilseed crops, groundnut has first place in the country. In Gujarat, groundnut is grown in an about 20 lakh hectares area with total production of about 26 lakh tonnes annually. Summer groundnut is cultivated in Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat and Maharashtra states where assured irrigation facilities are available. The main problems limiting production of groundnut are poor cultural practices as well as inadequate weed management. The weed flora in groundnut varies with agro-ecological conditions and the level of management. Weeds in groundnut belong to diverse species of narrow- and broad-leaved weeds and sedges. The extent of yield losses was around 62% during the *Kharif* season and up to 47% during the summer season. An experiment was carried out, to study the efficacy of herbicide mixture on weeds and yield of summer groundnut, during the year 2020 at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand in loamy sand soil. Twelve treatments were tested using randomized block design with three replications. The dominant weed species observed in the experimental field were: *Eleusine indica* L., *Dactyloctenium aegyptium* L. (Willd) and *Eragrostis major* L. among monocots and *Digera arvensis* L., *Boerhaavia diffusa* L., *Chenopodium album* L. and *Chenopodium murale* L. among dicots. The rest of the weed species occurred were considered as other weeds. Significantly lower density and biomass of total weeds and 30 days after seeding (DAS) and at harvest was observed with interculturing (IC) twice and hand weeding (HW) twice at 20 and 40 DAS and it was statistically at par with pre-emergence application (PE) of pendimethalin (30%) + oxyfluorfen (23.5%) EC (tank mix) 900 + 120 g/ha. They have recorded more than 86% weed control efficiency at harvest. Post-emergence application (POE) of sodium-acifluorfen (16.5%) + clodinafop-propargyl (8%) EC (pre-mix) 245 g/ha (T_{10}) failed to provide effective control of monocot and dicot weed at harvest. Whereas, fluazifop-p-butyl (11.1%) + fomesafen (11.1%) SL (pre-mix) 250 g/ ha EPoE and PoE showed slightly phytotoxic effect at 7 DAS but later on it recoveedr. Pendimethalin (30%) + oxyfluorfen (23.5%) EC (tank mix) 900 + 120 g/ha and IC *fb* HW at 20 and 40 DAS recorded higher plant dry biomass at harvest, nodule dry weight (mg/plant) at 45 DAS, higher pod yield, maximum net realization and benefit cost ratio of summer groundnut.

Evaluation of suitable herbicides for efficient weed control in irrigated groundnut at Puducherry Region

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Groundnut is important oil, food and forage crop of the country. India is the second largest producer of groundnut in the world. The rapid increase in population growth rate necessitates phenomenal increase in crop productivity. Weed competition is going to be the major constraints in achieving higher productivity as the yield losses due to weeds range from 15 to 30%, due to shortage of labour or scarcity of water and energy, electricity *etc*. Currently, several herbicidal formulations are available in the market used as pre- and post-emergence herbicides for controlling weed complex. It is necessary to incorporate the chemical methods in integrated weed management practices. Thus three experiments were conducted in order to evaluate and identify suitable herbicides for efficient weed control in groundnut at Puducherry Region under irrigated condition. at Perunthalaivar Kamaraj Krishi Vigyan Kendra (PKKVK), Puducherry State experimental farm in a randomized block design with three replications. The tested treatments were: T1- pre-emergence application (PE) of pendimethalin 0.75 or 1.0 kg/ha, T2- pendimethalin 30EC + imazethapyr 2 EC 1.0 kg/ha (ready mix), T3- pendimethalin 0.75 or 1.0 kg/ha (PE) followed by (*fb*) post-emergence application (PoE) of quizafop – p- ethyl 50 g/ha at 15-20 DAS, T4-,T5- pendimethalin 0.75kg/ha PE *fb* imazethapyr 75 g/ha PoE at 15-20 DAS, T6- pendimethalin 0.75 or 1.0 kg/ha PE *fb* manual weeding at 25-30 DAS, T7- pendimethalin 30EC + Imazethapyr 2 EC 1.0 kg/ha (ready mix) PE *fb* manual weedingat 25-30 DAS, T8- manual wedding twice at 20 and 40 DAS, T9- weedy check. The three seasons pooled data indicated that pendimethalin 30EC + imazethapyr 2 EC 1.0 kg/ha (ready mix-Valor 32) PE *fb* quizafop – p-ethyl 50 g/ha PoE at 15-20 DAS recorded significantly the pod yield (3922 kg/ha) as compared to control (2904 kg/ha) and it remained at par with pendimethalin 30EC + Imazethapyr 2 EC 1.0 kg/ha (ready mix-Valor 32) PE *fb* manual weeding at 25-30 DAS (3801 kg/ha) with highest weed control efficiency (85.1%) and nearly 18-35% increase in pod yield over control.

Efficacy of pre- and post-emergence herbicides on weed management in groundnut

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Groundnut (*Arachis hypogaea* L.) is a major oilseed crop and widely grown in tropical and sub-tropical regions and in the continental part of temperate countries in the world. It is mainly grown in semi-arid regions of the country and its kernel contains about 49.24% edible oil. Amongst the various biotic stresses resulting for it's low productivity, weeds are considered as a major constraint, especially under irrigated eco-system. The most crucial period of weed competition is from 3-6 weeks after sowing as these incur most damage during early growth period *i.e.* up to 45 days. The loss of yield in groundnut up to 30% due to early period competition and up to 60% due to poor management. Chemical weed control is, however, not a substitute for physical, cultural and biological control rather it is employed to bridge up gaps in these methods. Increasing labour cost and scarcity, drudgery, increasing energy and fuel cost, and in many situations inefficient weed control options force to choose chemical weed control as an efficient and economical alternative. Under these circumstances, chemical weed control through the application of herbicide is gaining popularity among the farming community. A field experiment was conducted at Agricultural Research Station, Mandor, Agriculture University, Jodhpur during *Kharif,* 2019 in order to control groundnut associated weed growing in *Kharif* season. An experiment was done with thirteen treatments of pre- and post-emergence herbicides comprising weedy cheek and weed free check replicated thrice in randomized block design (RBD). The various weeds observed in groundnut field during *Kharif* season were, *Amaranthus viridis, Celosia argentea, Corchorus trilocularis, Digera arvensis, Phyllanthus niruri, Portulaca oleracea, Tribulus terristris*, *Cynodon dactylon, Dactyloctenium aegyptium, Eragrostis minor*, *Cyperus rotundus* and *Cyperus esculentus*. Maintenance of weed free condition resulted in significant reduction in weed density and weed dry weight at harvest. Among different herbicides treatments, application of pendimethalin + imazethapyr at 1.0 kg/ha (PE) + one manual weeding at 30 DAS and pendimethalin at 1.0 kg/ha (PE) + imazethapyr at 75 g/ha at 20 DAS significantly reduced total weed density and weed dry weight at harvest. Similarly, significantly increased the number of pods/plant (14.5), number of kernels/pod (1.8), pod yield (3.42 t /ha) and haulm yield (7.05 t /ha) were also recorded with pendimethalin + imazethapyr at 1.0 kg /ha (PE) + one manual weeding at 30 DAS as compared to weedy check but was at par with pendimethalin at 1.0 kg/ha (PE) + imazethapyr at 75 g/ha 20 DAS, pendimethalin at 1.0 kg/ha (PE) + one manual weeding at 30 DAS and pendimethalin + imazethapyr at 1.0 kg/ha (PE) + quizalofop-ethyl at 50 g/ha 20 DAS. The highest net returns (₹ 1,47,438/ha) and B:C ratio (3.44) were obtained under pendimethalin at 1.0 kg/ha (PE) + imazethapyr at 75 g/ha 20 DAS *fb* pendimethalin + imazethapyr at 1.0 kg/ha (PE) + one manual weeding at 30 DAS.

Integrated weed management in groundnut

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Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of India. It is second most important source of vegetable oil in the world. Yield loss in groundnut due to weed infestation ranged from 74 to 92%. Critical period for crop-weed competition in groundnut was reported up to 40-60 days after seeding (DAS) and weed free environment during this period registered higher pod yield. The initial growth (generally 6 weeks) of groundnut and its inter row area covering by its canopy is relatively slow which facilitates maximum weed growth and making weeds strongly compete with the crop causing significant reduction in groundnut yield. Besides, weeds compete for growth resources (underground space, water, nutrient and light) with the crop, hinder pegging, pod development and make harvesting of groundnut cumbersome. Common weed flora in groundnut: annual grasses *i.e Eleusine indica, Dactylocteium aegyptium, Digitaria sanguinalis,* anuual broad-leved weeds *i.e Digera arvensis, Heliotropium indicum, Tribulus terrestris, Euphorbia hirta, Eclipta alba, Parthenium hysterophorus* and perennial weeds *i.e Cynodon dactylon, Cyperus esculentus, Cyperus rotundus, Convolvulus arvensis*. Weeds also affected groundnut through the production of harmful allelochemicals. Thus, weed control is the foremost critical production factor in groundnut cultivation. In this paper, various physical, chemical, mechanical and cultural methods that curtail the growth and spread have been discussed. Seed bed preparation free from weeds. Two Hand weeding twice is advised at critical weed competition period *i.e* one hand weeding at 20-25 DAS before pegging initiates and second-hand weeding is adopted at once pegging started appears inhibitory to groundnut yield, but under unavoidable situation of severe weed infestation, hand pulling of weeds may be advocated at 40-45 DAS with minimum soil disturbance. Mulching and tillage practices also reduce the weeds growth and increase the yield of groundnut through the maintenance of moisture content. In chemical weed control fluchloralin 0.75-1.0 kg/ha and imazethpyr+pendimethalin 0.8 kg/ha is applied as pre-plant incorporation for controlling annual weeds and some broad-leaved weeds, pendimethalin 0.75-1.0 kg/ha and alachlor 1.0-1.5 kg/ha are applied as pre-emergence for many grass weeds and few broad-leaved weeds and fluazifop-p-butyl 0.125 kg/ha at 13-15 DAS and 0.250 kg/ha at 25-30 DAS for controlling annual and perennial grasses, diclofop-methy l 0.75-1.0 kg/ha can be applied as post-emergence for controlling many annual grasses.

Effect of weed management on weed, yield attributes and yieldof groundnut

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Groundnut is an important oilseed crop of India. Among the various factors, which influence the crop production, weed flora is a single negative factor and serious menace which plays key role against achieving high yield potential of the crop. In rainy season, weeds are serious problem due to favorable conditions for their growth. Cultural as well as mechanical practices such as hand weeding and interculturing are effective but unavailability of labors and continuous rainfall during *Kharif* season does not permit it to operate timely. The current trends and further development of intensive agriculture likely to seek the help of herbicide as an effective tool for weed control. Thus, a field experiment was carried out during *Kharif* 2009-10 to 2011-12 at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Gujarat to find out the effect of weed management on yield attributes, yield and economics of groundnut. Total nine treatments were evaluated, *viz.* quizalofop-p-ethyl 50 g/ha as post-emergence application (PoE) at 15-20 DAS; quizalofop-p-ethyl 75 g/ha PoE at 15-20 days after seeding (DAS); pendimethalin 1000 g/ha as pre-emergence application (PE) followed by (*fb*) quizalofop-p-ethyl 50 g/ha PoE at 15-20 DAS; imazethapyr 75 g/ha PoE at 15-20 DAS; imazethapyr 100 g/ha PoE at 15-20 DAS; pendimethalin 1000 g/ha PE *fb* imazethapyr 75 g/ha PoE at 15-20 DAS, pendimethalin 1000 g/ha PE; intercultivation (IC) and hand weeding (HW) twice at 20 and 40 DAS; weed free and weedy check in randomized block design with four replications. A uniform basal dose of N and P (12.5 and 25 kg/ha, respectively) was applied at the time of sowing. The three years experimental results revealed that, significantly higher number of mature pods per plant, shelling percent, pod yield, haulm yield as well as higher net returns and B:C ratio due to effective weed control as indicated by lower weeds biomass, higher weed control efficiency and lower weed index were observed under weed free treatment which was found on par with pendimethalin 1000 g/ha PE *fb* imazethapyr 75 g/ha PoE at 15-20 DAS and hand weeding followed by interculturing at 20 and 40 DAS. Moreover, there was no any residual effect of herbicides on plant population per metre row length, grain and straw yield of subsequent wheat crop.

Efficacy of new herbicide molecules for weed management in groundnut

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Weed infestation is the major biotic factor among various biotic and abiotic factors responsible for low productivity of groundnut. As groundnut is grown mainly in the rainy season when the condition is more favorable for weed growth, that encourage repeated flushes of grasses and broad-leaved weeds during the entire season for competition with the crop, more specifically during early stages of crop growth. The yield loss of groundnut in India due to weeds ranged from 24-70%depending on type of weed flora associated with groundnut. The critical period for crop-weed competition was reported to be up to 45 days after sowing. Thus, weed control is the most critical production factor in groundnut. Hence, a field experiment was conducted at Agronomy Instructional Farm, Sardarkrushinagar, Dantiwada Agricultural University, Sardarkrushinagar during *Kharif* 2021 to assess efficacy of some new herbicide molecules for weed management in groundnut (*Arachis hypogaea* L.) on loamy sand soil. The experiment ten weed management treatments, *viz.* pendimethalin 1000 g/ha pre-emergence application (PE), diclosulam 22 g/ha PE, sulfentrazone 28 + clomazone 30 WP 350 + 375 g/ha PE, sodium acifluorfen 16.5 + clodinafop-propargyl 8 EC 165+80 g/ha post-emergence application (PoE), imazethapyr 100 g/ha POE, fluthiacet-methyl 13.6 g/ha POE, imazethapyr 35 WG + imazamox 35 WG 70 g/ha POE, interculturing and hand weeding at 15 and 30 days after seeding (DAS), hand weeding twice at 20 and 40 DAS and unweeded check. Groudnut variety '*TG 37*' was used and sown at a distance of 45 cm between the rows. The predominant weed flora observed in experimental field were: *Cyperus rotundus* L. among sedges, *Cynodon dactylon* L., *Digitaria marginata* L., *Digitaria sanguinalis* L. and *Dactyloctenium aegyptium* L. among grasses and *Portulaca oleracea* L., *Boerhavia erecta* L., *Tribulus terrestris* L, *Leucas aspera*., *Digeria arvensis* L., *Commelina benghalensis* L. and *Amaranthus viridis* among broad-leaved weeds. Among different treatments, hand weeding twice at 20 and 40 DAS recorded significantly higher pod and haulm yield (1.98 and 3.08 t/ha, respectively) and found at par with interculturing and hand weeding at 15 and 30 DAS (1.89 and 2.95 t/ha, respectively), sodium acifluorfen 16.5 + clodinafop-propargyl 8 EC 165+80 g/ha PoE (1.84 and2.86 t/ha, respectively) and imazethapyr 35 WG + imazamox 35 WG 70 g/ha PoE (1.80 and 2.81 t/ha, respectively) which was mainly due to significantly lower density and biomass of grasses, sedges, broad-leaved and total weeds with higher weed control efficiency (76.99 - 83.96% at 60 DAS; 77.97 - 83.97% at harvest) and lower weed index (0.00 - 9.04%) observed in these treatments as compared to unweeded check (0.85 t/ha pod yield and 1.33 t/ha haulm yield). Based on results of the field experiment, it is concluded that higher pod and haulm yield in *Kharif* groundnut can be obtained with either hand weedings twice at 20 and 40 DAS or interculturing followed by hand weeding at 15 and 30 DAS or sodium acifluorfen 16.5 + clodinafop-propargyl 8 EC 165+80 g/ha PoE or imazethapyr 35 WG + imazamox 35 WG 70 g/ha PoE.

Effect of different weed management practices and fertility levels on weed dynamics in groundnut

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Groundnut is highly susceptible to weed infestation because of its slow initial growth up to 40 days after seeding (DAS) and small foliage cover. The presence of weeds for long time in the field hinders pegging, affects the pod size, competes for underground space. After peg initiation, the use of mechanically operated power weeder is detrimental to crop. On the other hand, use of herbicides is also limited due to their selectivity. Thus, integration of methods is followed by combining herbicides with manual, cultural and mechanical weed control methods. Thus, a study was conducted to assess the effect of weed management treatments on weed dynamics in groundnut. The study was carried out on a sandy loam soil during summer, 2021 at AICRP on weed management block, OUAT, Bhubaneswar. The treatments consisted of four weed management practices W_1: pre-emergence application (PE) of pendimethalin 0.75 kg/ha, W_2: pretilachlor 0.5 kg/ha PE, W_3: manual weeding twice at 20 and 40 DAS, W_4: Twin wheel hoe at 20 DAS followed by (*fb*) hand weeding at 40 DAS and four fertility levels T_1: 100% recommended dose of fertilise (RDF) (20:40:40: kg N: P_20_5: K_2O kg/ha), T_2: 75% RDF + 5 tonnes FYM/ha, T_3: 50% RDF + 10 tonnes FYM/ha, T_4: without fertilizer + without FYM. Sixteen treatment combinations were tested in factorial randomized complete block design with three replications. The predominant grassy weeds were *Digitaria sanguinalis, Digitaria ciliaris, Dactyloctenium aegyptium, Elusine indica and Echinochloa colonum*. Among broad-leaved weeds; *Borreria hispida, Cleome viscosa, Cleome rutidosperma, Celosia argentea, Croton sparsiflorus, Eclipta alba, Phyllanthus niruri, Physalis minima and Tephrosia purpurea* were common in the field, and the only dominant sedge was *Cyperus rotundus*. The use of twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS significantly reduced the total weed density (6.6 /m^2), weed biomass (8.5 g/m^2) and recorded the highest weed control efficiency (69.8%). The fertilizer management of 50% RDF + 10 tonnes FYM/ha registered the lowest weed density (6.6 /m^2), weed biomass (8.3 g/m^2) with highest weed control efficiency (71.8%). Groundnut under weed management with twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS along with application of 50% RDF + 10 tonnes FYM/ha was the most effective strategy for controlling the weed menace with highest weed control efficiency.

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Effect of integrated weed management in linseed under South Gujarat condition

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A field experiment was conducted at College Farm, Navsari Agricultural University, Navsari (Gujarat) during *Rabi* season of the year 2016-17 to study the integrated weed management in linseed (*Linumu sitatissimum* L.) under south Gujarat condition. The experiment was laid out in randomized block design with three replications and twelve weed management treatments. The seed yield, stover yield, minimum weed biomass and lower weed index were observed under weed free. In case of chemical weed control, significantly higher seed yield (1417 kg/ha), stover yield (2872kg/ha), minimum weed biomass at 60 DAS and at harvest (4.91 g/m^2 and 100.3 kg/ha, respectively), lower dicot weeds, lower weed Index and maximum net return (82159 /ha) were recorded with pre-emergence application (PE) of pendimethalin 0.75 kg/ha followed by (*fb*) post-emergence application (PoE) of 2,4-D 0.5 kg/ha at 40 days after seeding (DAS), which was at par with hand weeding twice at 20 DAS and 40 DAS and pendimethalin 0.75 kg/ha PE *fb* one hand weeding at 40 D*AS.* It is concluded that for achieving production potential, higher profit and effective weed control in linseed crop, maintain weed free condition with hand weeding throughout crop growth period, where labours are easily available. In case of labours scarcity, pendimethalin 0.75 kg/ha PE *fb* 2,4-D 0.5 kg/ha PoE at 40 DAS may be opted as it is equally effective.

Management of chocolate weed (*Melochia corchorifolia* L.) in sesame

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Sesame (*Sesamum indicum* L.) is the most widely cultivated oilseed crop of Kerala, and was mainly cultivated in *Summer* rice fallows in the Onattukara sandy plains. Chocolate weed (*Melochia corchorifolia* L.), a member of Malvaceae family poses a threat to sesame cultivation in the tract due to its prolific seed production ability and mixing of it's seed with sesame seed due to their seed morphological similarity. Herbicide use is limited for the management of chocolate weed in sesame since it is a broad-leaved weed. Sesame is particularly sensitive to majority of the Pre- and Post-emergence herbicides commonly used in oilseed crops. The present study was undertaken with an objective to develop a cost-effective weed management method for chocolate weed in sesame. Field experiments were conducted for two consecutive *summer* seasons (2021 and 2022) at Onattukara Research Station (ORARS), Kayamkulam, Kerala with nine treatments replicated thrice. Treatment comprised of: stale seedbed (SSB) + post-direct application (PDA) of glufosinate-ammonium 375 g/ha at 20 days after seeding (DAS) followed by (*fb*) wheel hoe weeding (WHW) at 45 DAS (W_1), SSB + carfentrazone ethyl 20 g/ha PDA at 20 DAS *fb* WHW at 45 DAS (W_2), SSB + pre-emergence application (PE) of pendimethalin 500 g/ha *fb* glufosinate ammonium 375 g/ha PDA at 20 DAS (W_3), SSB + pendimethalin 500 g/ha PE *fb* carfentrazone ethyl 20g/ha *P*DA at 20 DAS (W_4), W_3 + WHW at 45 DAS (W_5), W_4 + WHW at 45 DAS (W_6), SSB + hand weeding at 20 and 40 DAS (W_7), SSB alone (W_8) and weedy check (W9). Post direct application of post-emergence herbicides were carried out with the aid of a specially designed crop protective herbicide applicator for which innovation patent was applied (Application No. 202141013242 dt. 25.03.20210) as well as WHW was done using a specially designed hoe weeder (Design patent granted No. 100961 dt.11.08.2021).'*Thilak*', a black seeded 85 days duration sesame variety released by ORARS was used in the experimentation. 500 l/ha spray volume was used for herbicides application. Chocolate weed and Asian spider flower (*Cleome viscos*a L.) were the two prominent weed species in the experimental field during both the years. Pooled analysis of both the years revealed that chocolate weed recorded a relative density of 97.8% at 60 DAS. Adoption of SSB alone resulted in reduction in the density and biomass of chocolate weed of 15.2% and 32.9%. Among the weed management treatments, SSB + pendimethalin 500g/ha PE *fb* carfentrazone ethyl 20 g/ha *P*DA at 20 DAS and WHW at 45 DAS (W_6) resulted in the lowest density and biomass of chocolate weed. Significant reduction in the biomass of chocolate weed lead to higher weed control efficiency of 93.1% at 60 DAS. Sesame yield decreased by 73.2% due to infestation of chocolate weed. The treatment (W_6) resulted in the highest sesame yield (441 kg/ha), maximum gross return (65889 ₹/ha), net return (24115 ₹/ha) and B:C ratio (1.57) and hence, it could be recommended as the most effective strategy for the management of chocolate weed in sesame.

Growth, yield and quality of sesame as influenced by nitrogen levels and weed management practices under south Gujarat condition

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A field experiment was conducted on heavy black soil at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during the summer season 2019-20. The study consisted combinations of three levels of nitrogen, *viz.* 25 kg N/ha (N_1), 50 kg N/ha (N_2) and 75 kg N/ha (N_3) and seven weed management practices, *viz.* weedy check (W_1), weed free check (W_2), hand weeding (HW) at 30 DAS (W_3), pre-emergence application (PE) of pendimethalin 0.75 kg/h (W_4), pendimethalin 0.75 kg/ha PE followed by (*fb*) One HW at 30 DAS (W_5), post-emergence application (PoE) of quiazalfop-ethyl at 20 DAS 0.05 kg/ha (W_6) and pendimethalin 0.75 kg/ha PE *fb* quiazalfop-ethyl PoE at 30 DAS 0.05 kg/ha (W_7). A randomized block design with three replications was used. Higher values of all the growth and yield attributes such as plant height, number of leaves per plant, number of primary branches per plant, length of capsule, number of capsule per plant, number of seed per capsule, seed yield per plant and weight of 1000 seeds were recorded with 75 kg N/ha (N_3). In case of weed management treatments, significantly higher values were recorded under weed free check (W_2) which remained at par with treatments W_3, W_5 and W_7. Significantly highest seed yield (0.954 t/ha) and stover yield (1.560 t/ha) were recorded with 75 kg N/ha (N_3). In case of weed management practices significantly higher seed yield (0.971 kg/ha) and stover yield (1.640 kg/ha) were recorded with weed free check (W_2) which remained at par with treatments W_3 (HW at 30 DAS), W_5 (pendimethalin 0.75 kg/ha PE *fb* One HW at 30 DAS) and W_7 (pendimethalin 0.75 kg/ha PE quiazalfop-ethyl 0.05 kg/ha PoE at 30 DAS). In case of oil content, significantly higher oil yield, protein content, protein yield, NPK content and uptake of sesamum were recorded with 75 kg N/ha (N_3) and W_2 (weed free check) in weed management practices followed by treatment W_5 (pendimethalin 0.75 kg/ha PE *fb* One HW at 30 DAS). Lower weed density and weed index with higher weed control efficiency were recorded in weed free check (*fb* W_2), which was followed by pendimethalin 0.75 kg/ha PE *fb* One hand weeding at 30 DAS (W_5).

Effect of weed management practices on weed dynamics and yield performance of castor

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A field experiment was conducted during three consecutive *Rabi* season of 2016-17, 2017-18 and 2018-19 at Centre for Oilseeds Research, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India. The soil of the experimental field was loamy sand in texture having pH 7.1 to 7.5, low in available nitrogen, medium in available phosphorus and potassium. The experiment was laid out in randomized block design comprised of eight treatments, *viz.* Pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 DAS (T_1), Pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 & 60 DAS (T_2), Quizalofop ethyl 0.05 kg/ha (post-emergence at 20 DAS) + HW at 60 DAS (T_3), Pendimethalin 1 kg/ha (pre-emergence) + Quizalofop ethyl 0.05 kg/ha (post-emergence at 20 DAS) (T_4), Pendimethalin 1 kg/ha (pre-emergence) + Quizalofop ethyl 0.05 kg/ha (post-emergence at 20 DAS) + HW at 60 DAS (T_5), Two hand weedings (at 30 & 60 DAS)/Farmers' practice (T_6), weed free (HW at 20 with IC, 40, 60, 80, 120 & 150 DAS) (T_7) and unweeded control (T_8) replicated thrice. The castor crop was sown at a distance of 150 cm × 120 cm row and plant to plant spacing with gross plot size of 12.0 m × 6.0 m. The major weed flora found in experimental field recorded was, *viz.*, *Cynodon dactylon, Cyperus rotundus, Digitaria sanguinalis, Commelina benghalensis, Ipomoea pestigridis, Digera arvensis, Trianthema* spp., *Euphorbia hirta, Alternanthera etc*. The weeds were counted at 20, 40 and 60 DAS randomly in each plot using 0.5 x 05 m quadrate. Among weed management practices, weed free crop produced higher seed yield (3304 kg/ha) and maintained its significant superiority over rest of the treatments. However, application of pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 & 60 DAS (T_2) and pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 DAS (T_1) performed statistically on par to each other but were superior to the rest of treatments. The yield attributing parameters like plant height, nodes/plant and oil content were statistically not influenced due to various weed management treatments. Weed dry weight recorded at 20 and 60 DAS found the lowest with the application of pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 & 60 DAS (T_2), but at 40 DAS it was registered lowest with pendimethalin 1 kg/ha (pre-emergence) + quizalofop ethyl 0.05 kg/ha (post-emergence at 20 DAS) + HW at 60 DAS (T_5). Based on three years pooled data, weed free crop, application of pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 DAS (T_1) & pendimethalin 1 kg/ha (pre-emergence) + IC *fb* HW at 40 DAS and 60 DAS (T_2) recorded higher net returns and B: C ratio (2.87 & 2.71) over rest of the treatments.

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Enhancing productivity and profitability through integrated weed management in summer

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Sesame (*Sesamum indicum* L.) is the oldest oilseed crop used by man since antiquity. Sesame is drought resistant, high in oil and protein, and presence of minerals and amino acids. Weed infestation is the major biological constraint limiting sesame yield. Manual hand hoe weeding, though laborious and expensive is the most common traditional weed management method in Onattukara, Kerala. In order to reduce the dependence on human labour for weeding, it is indispensable to develop an integrated approach involving both chemical and non-chemical methods. Integrated weed management has the potential to save human labour, restrict weed populations to manageable levels, reduce the environmental impact of individual weed management practices, and reduce selection pressure for weed resistance to herbicides. A field experiment was conducted at Onattukara Regional Agricultural Research Centre, Kayamkulam, Kerala during the *summer* 2021-22 to find out the efficacy of integrated weed management practices on the growth, yield, and economics of sesame (*Sesamum indicum* L.). The experiment was laid out in a randomized block design with nine treatments in three replications. Treatments include T_1: Oxyflourfen 80 g/ha at 0-5 DAS + carfentrazone ethyl 20 g/ha at 20-25 DAS; T_2: Oxyflourfen 80 g/ha at 0-5 DAS+ imazethapyr 50 g/ha at 20-25 DAS; T_3: Oxyflourfen 80 g/ha at 0-5 DAS + mechanical weeding with wheel hoe weeder at 25 DAS; T_4: Pendimethalin 500 g/ha at 0-5 DAS + carfentrazone ethy l20 g/ha at 20-25 DAS; T_5: Pendimethalin 500 g/ha at 0-5 DAS + imazethapyr 50 g/ha at 20-25 DAS; T_6: Pendimethalin 500 g/ha at 0-5 DAS + mechanical weeding with wheel hoe weeder at 25 DAS; T_7: Mechanical weeding with wheel hoe weeder at15 and 30 DAS; T_8: Hand hoe weeding at 15 and 30 DAS; T_9: Weedy check. The weed flora of experimental fieldwas mainly comprised of *Cyperus rotundus, Melochia corchorifolia, Digitaria ciliaris*. There was a predominance of dicot chocolate weed *Melochia corchorifolia*. Results revealed that pendimethalin 500 g/ha at 0-5 DAS followed by either mechanical weeding with wheel hoe weeder at 25 DAS or carfentrazone ethyl 20 g/ha at 20-25 DAS were equally effective in controlling the weeds and improving growth and ultimately seed yield (561 and 555 kg/ha) and haulm yield (1080 and 1073 kg/ha) of sesame. Among the treatments, maximum net returns of ₹ 63102/ha and B: C ratio of 3.27 were recorded under pendimethalin 500 g/haat 0-5 DAS followed by mechanical weeding with wheel hoe weeder at 25 DAS, therefore, this integrated weed management practice could become effective and economical under Southern Coastal Plains of Kerala.

Effect of weed competition period on growth and yield ff grain Amaranth

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An investigation was carried out during *Rabi* season of 2019-20 at College Farm, Department of Agronomy, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The experiment was laid out in Randomized Block Design having ten treatments compr-ising of T1 (weed free upto 15 DAS), T2 (weed free upto 30 DAS), T3 (weed free upto 45 DAS), T4 (weed free upto 60 DAS), T5 (weed free upto harvest), T6 (weedy upto 15 DAS), T7 (weedy upto 30 DAS), T8 (weedy upto 45 DAS), T9 (weedy upto 60 DAS), T10 (Weedy upto harvest) with three replications. Almost all the growth and yield attributes as well as yield were significantly influenced due to various treatments. Plant height of grain Amaranth at 60 DAS and at harvest significantly affected, but at 30 DAS were not affected significantly by different treatments but increased progressively upto harvest with advancement of crop growth. At harvest, treatment T5 had higher stem girth (5.62 cm), length of spike (72.24 cm) and maximum numbers of spikelets (65.20) which was at par with treatments T4. The higher grain yield (1250 kg/ha) and stover yield (3127 kg/ha) were obtained under treatment T5 and remained at par with treatments T4, T3 and T6. The dry weight of total weeds recorded at 60 DAS and at harvest was reduced significantly by all the treatments as compared to T10 (weedy up to harvest). Looking to the periodical data on total dry weight of weeds i.e., 60 DAS and at harvest, treatment T5 recorded the lowest dry weight of weeds, closely followed by treatments T6, T7, T8 and T4. The treatments T3 and T2 also recorded the lower dry weight of total weeds. The response of different treatments in terms of weed competition indexwas found in order of T5<T4<T3<T6<T7<T2<T8<T1<T9<T10. Maximum weed control efficiency (100%) was observed in treatment T_5 which was followed by in the trend of T4> T6> T3> T7> T2> T8> T1> T9.

Yield, economics and quality of grain amaranth (*Amaranthus hypochondriacus* L.) influenced by integrated weed management

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A field experiment, to quantify yield and quality of grain amaranth (*Amaranthus hypochondriacus* L.) as influenced by integrated weed management, was conducted during *Rabi* season of 2020-21 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The experimental field's topography was fairly uniform and levelled. The soil of experimental field was loamy sand in texture with low in organic carbon and available nitrogen (138 kg/ha), medium in available phosphorus (43 kg/ha) and high in available potassium (281 kg/ ha) having pH value of 7.56. The higher values of growth attribute, *viz.*, plant height at harvest and yield attributes, *viz.*, length of inflorence were recorded with weed free which remained at par with oxyflurofen 50 g/ha pre-emergence application (PE) and interculturing followed by (*fb*) hand weeding at 4 weeks after seeding (WAS). Significantly highest grain yield per plant and grain yield were recorded under weed free as compared to rest of other treatments. Among the integrated weed management treatments, oxyflurofen 50 g/ha PE and interculturing *fb* hand weeding at 4 WAS gave significantly higher grain yield per plant and grain yield as compared to other treatments. Significantly higher straw yield was recorded with weed free t which was at par with oxyflurofen 50 g/ha PE and interculturing *fb* hand weeding at 4 WAS. The maximum net return was obtained with weed free and it was closely followed by oxyflurofen 50 g/ha PE and interculturing *fb* hand weeding at 4 WAS. Whereas, the highest B:C ratio was obtained with oxyflurofen 50 g/ha PE and interculturing *fb* hand weeding at 4 WAS which was closely followed by weed free treatment. I It is concluded that higher yield and maximum net return in grain amaranth can be achieved by maintaining weed free condition throughout crop growth period where labours are easily available. However, under the scarcity of labours, the higher yield and maximum B:C ratio can be achieved with oxyflurofen 50 g/ha PE and interculturing fb hand weeding at 4 WAS.

Integrated weed management in summer sesame

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An experiment was conducted on heavy black soil having clay in texture, low in available nitrogen (276 kg/ha), medium in available phosphorus (40.30 kg/ha), fairly rich in available potassium (369.80 kg/ha) and slightly alkaline in reaction (pH 7.8) at College Farm, Navsari Agricultural University, Navsari during the summer season of 2016. The investigation carried out with sesame variety *GT-3* and fertilized with 50-25-0 N-P_2O_5-K_2O kg/ha. The experiment comprising eleven treatment combinations were laid out in randomized block design and replicated thrice. The treatment combinations include: W_1: pre-emregence application (PE) of pendimethalin 0.75 kg/ha, W_2 : pendimethalin 0.75 kg/ha PE followed by (*fb*) hand weeding (HW) and interculturing at 30 days after seeding (DAS), W_3 : m iazethapyr 75 g/ha as post-emergence application (PoE) at 20-25 DAS, W_4 : m iazethapyr 100 g/ha PoE 20-25 DAS, W_5 : pendimethalin 0.75 kg/ha PE *fb* imazethapyr 100 g/ha PoE 20-25 DAS, W_6 : imazethapyr 100 g/ha PoE 20 DAS *fb* HW and interculturing at 40 DAS, W_7 : pendimethalin 0.75 kg/ha PE *fb* imazethapyr 75 g/ha PoE 20-25 DAS, W_8 : m iazethapyr 75 g/ha PoE 20 DAS *fb* hand weeding and interculturing at 40 DAS, W_9 : a hnd weeding and interculturing twice at 20-40 DAS, W_{10} : e wed free check) and W_{11} : e wedy check). The experimental field was infested by monocot weeds; *Echinochloa crusgalli*, *Digitaria sanguinalis*, *Sorghum halepense*, *Cynodon dactylon* and among dicot weeds; *Amaranthus viridis*, *Alternanthera sessillis*, *Digera arvences* and *Convolvulus arvensis* and the sedge: *Cyprus rotandunce*. Weed free check recorded significantly lowest pweed density and biomass followed by W_9: a hnd weeding and inter culturing twice at 20-40 DAS) and W_2: pendimethalin 0.75 kg/ha PE *fb* hand weeding and inter culturing at 30 DAS. The lowest weed index (3.72%) and highest weed control efficiency (67.93%) were observed with W_9: HW and inter culturing twice at 20-40 DAS followed by W_2. The maximum seed yield (1020.8 kg/ha) was obtained with W_{10} : weed free check) which was statistically at par with W_2 and W_9. The highest net return of Rs 54,758/ha and BCR of 2.93 were recorded with hand weeding and inter culturing twice at 20-40 DAS (W_9), followed by f pendimethalin 0.75 kg/ha PE *fb* hand weeding and inter culturing at 30 DAS (W_2) with B:C ratio of 2.87. It can be concluded that higher weed control efficiency and yield of sesamum can be obtained by hand weeding and interculturing twice at 20 and 40 DAS or pendimethalin 0.75 kg/ ha PE *fb* one hand weeding and interculturing at 30 DAS.

Evaluation of pre- and post-emergence herbicides for weed management in sesame

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The field experiment was carried out at Oilseeds Research Station, JalgaonMaharashtra during *Kharif* 2020 for the evaluation of pre- and post-emergence herbicides for weed management in sesamum with an object to find out suitable weed management practices insesame. The experiment comprised of eight treatments laid out in a randomized block design with three replications. The sesamum variety *JLT-408* was sown on 01-07-2020 in a plot of size 4.10m x3.60m. Different weed control treatments have significantly influenced the weed population, growth and yield of sesame. Growth characters, *viz.* plant height (cm), number of leaves per plant, number of capsule per plant, capsule length (cm) and number of seeds per capsule were significantly more under weed free treatment than those in registered in rest of weed control treatments in study, while they were lower in weedy check. In respect of growth characters, pendimethalin pre-emergence application (PE) 0.50 kg/ha (R) followed by (*fb*) hand weeding at 20 days after seeding (DAS) was at par with pendimethalin 0.50 kg/ha (R) PE + *fb* sodium-acifluorfen 16.5% + clodinafop-propargyl 8% EC (premix) 100 g/ha post-emergence application (PoE) at 20 DAS.Yield of sesame (kg/ ha) was found to be significantly higher (627 kg/ha) with weed free. Among the different herbicide treatments, pendimethalin 0.50 kg/ha (R) PE *fb* hand weeding at 20 DAS which significantly maximum yield (542 kg/ha) as compared to other treatments of weed control and it was found at par with pendimethalin0.50 kg/ha (R) PE *fb* sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC (premix)100 g/ha PoE at 20 DAS (504 kg/ha.).Among the herbicidal treatments tried in the experiment, application of pre-emergence herbicide followed by post-emergence herbicide treatment was found significantly better than application of post-emergence herbicide only in respect of yield of sesame probably due to better weed management resulting in improvement in all growth and yield parameters which contributed higher yield owing to favourable condition in absorbing soil moisture, nutrient content and sunlight penetration during crop growing period. From the economic point of view pendimethalin 0.50 kg/ ha (R) PE *fb* hand weeding at 20 DAS followed by followed by quizalofop-ethyl 50 g/ha PoE at 20 DAS are economical viable treatments based on economics *i.e.* B:C.

Effect of pre-emergence herbicide, pendimethalin, on the management of Cuscuta in Niger (*Guizotia abyssinica*)

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Niger (*Guizotia abyssinica* (L.f.) Cass.) is a crop of tribal region, extensively grown on the hill slopes and it is one of the most important major oilseed crops of tribal farmer of Anuppur district, Madhya Pradesh (M.P.). The oil of Niger crop is very good for curing heart disease. The crop is grown mostly in the light to sandy soil or barren land of *Kharif* season. The area under Niger crop is around 2987 hectare with average production of 1314 tons and productivity 440 kg/ha in Anuppur district which is very low as compare to the state average productivity. Cuscuta is major weed in Niger crop and the yield reduction of 60 to 70% was reported due to Cuscuta depending upon its intensity of infestation. Due to the damage caused by Cuscuta to the Niger crop its area and production has been reducing yearly in Anuppur district. Krishi Vigyan Kendra, Anuppur, Indira Gandhi National Tribal University, Amarkantak, M. P. carried out on-farm demonstration *Cuscuta* control in niger crop in 50 farmers fields of Village – Pamra & Bhundakona of Anuppur district during *Kharif* 2020 and *Kharif* 2021 under Cluster frontline demonstration scheme (CFLD). The variety demonstrated in farmer’s field under CFLD Scheme was JNC-9 released by Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur M.P. for hilly region. The study was carried out with objective of studying the efficacy of pre-emergence application (PE) of pendimethalin 0.75 kg/ha in managing Cuscuta in Niger crop. Higher average number of capsule per plant (36.4), average number of seeds per capsule (41.3), seed yield (0.56 t/ha), straw yield (0.94 t/ha), gross return (₹ 37957.0 /ha), net return (₹ 27676 /ha) and B:C ratio (3.70) were recordedwith pendimethalin 0.75 kg/ha PE. The farmers practise recorded lesser number of capsule per plant (26.9), average number of seeds per capsule (31.6), seed yield (0.32 t/ha), straw yield 0.87 t/ha), gross return (₹ 19948.0 /ha), net return (₹ 13398 /ha) and B:C ratio (3.0) than the pendimethalin 0.75 kg/ha PE. The increased yield and increased net income of farmer demonstrated in this extension activity is causing a gradual increase in the area, production and productivity of Niger crop in Anuppur district.

Productivity and profitability of clusterbean as influenced by weed management practices

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Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] popularly known by its vernacular name “Guar” is an important legume crop mainly grown under rainfed conditions of arid and semi-arid region of tropical India. The qualities of the crop like high adaptation towards erratic rainfall, multiple industrial uses and its importance in cropping system for factors such as soil enrichment properties, low input requirements *etc*. have made the guar one of the most significant crop for farmers in dry areas of India. Clusterbean is grown for different purposes, *viz.* vegetable, green fodder, green manuring, production of seed and cattle feed. In the recent years, besides its conventional uses, it has emerged as an industrial crop due to presence of galactomannan (gum) in its endosperm, which is around 28-33% of seed weight of clusterbean. A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *Kharif*, 2018 on loamy sand soil. The experiment comprises of 9 treatments *i.e.* weedy check, one hand weeding at 25 days after seeding (DAS), hand weeding twice at 25 and 45 DAS, pre-emergence application (PE) of pendimethalin750 g/ha, post-emergence application (PoE) of imazethapyr 75 g/ha, quizalofop-p-ethy 37.5 g/ha PoE, pendimethalin 750 g/ha PE + quizalofop-p-ethyl 37.5 g/ha PoE, pendimethalin 750 g/ha PE + imazethapyr 75 g/ha PoE, pendimethalin 30 EC + imazethapyr2 EC (RM) 750 g/ha PE. A randomized block design with three replications was used. The weed management practices markedly reduced crop-weed competition and influenced clusterbean yield significantly. The yield attributes (number of pods/plant, weight of pods/plant, number of seeds/pod) and yield (grain, stover and biological yields) were significantly higher with hand weddings twice at 25 and 45 DAS over weedy check and superior to all herbicides applied alone and one hand weeding at 25 DAS, but it was at par with pendimethalin 750 g/ha PE + imazethapyr 75 g/ha PoE, pendimethalin PE 750 g/ha + quizalofop-p-ethyl 37.5 g/ha PoE, pendimethalin 30 EC + imazethapyr 2 EC (RM) 750 g/ha as PE.Among all treatments, significantly maximum net returns (‘54920/ha) and B:C ratio (3.17) was acheived with pendimethalin 750 g/ha PE + imazethapyr 75 g/ha PoE which was closely followed by hand weeding twice at 25 and 45 DAS with ₹ 54608/ha net returns and 3.09 B:C ratio over rest of the treatments. The pendimethalin 750 g/ ha PE + imazethapyr 75g/ha PoE produced higher seed yield (1345 kg/ha), net returns (₹ 54920/ha) and B:C ratio (3.17) in clusterbean. Hand weeding twice at 25 and 45 DAS also proved equally effective in attaining higher seed yield (1385 kg/ha), net return (₹ 54608/ha) and B:C ratio (2.96). Hence it may be a preferred option if labour is easily and cheaply available.

Effect of pre-plant application of post-emergence herbicide glyphosate formulations on weeds and crops in the tomato-blackgram cropping sequence

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Weeds cause heavy yield losses when they compete with crops especially for light, water, nutrient and space. In crop production, weed management is a necessary operation to get a higher yield. Manual weeding operation is an easy and environmentally friendly method but it increases the cost of cultivation and is non-profitable. Thus, the herbicides can be used as the most practical and effective alternative means of weed control. Among the herbicides recommended for weed management in the non-cropped fields, glyphosate is most suitable post-emergence systemic herbicide to control all the emerged weeds leaving no residue after application. Glyphosate is a non-selective, systemic, post-emergence herbicide, directly applied to plant foliage. In plants, glyphosate affects the shikimic acid pathway through inhibition of the enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase. Field experiments were laid out at Tamil Nadu Agricultural University, Coimbatore during Winter 2021, Summer 2021 and *Rabi* (Confirmatory trial) 2021 to study the effect of pre-plant application of different doses of glyphosate on emerged weeds, tomato yield and its residual toxicity on succeeding blackgram germination. Tomato crop was raised during Winter, Summer and *Rabi* (Confirmatory trial) 2021 and the residual crop blackgram was sown after the harvest of tomato (except during confirmatory trial). Treatments comprised of glyphosate potassium salt at 875, 1125, 1375 and 2750 g/ha (T_1, T_2, T_3 and T_4), glyphosate IPA salt 41% SL at 1375 g/ha (T_5), metribuzin at 525 g/ha(T_6), hand weeding twice at 20 and 40 days after transplanting (DAT) (T_7), weed-free (T_8) and untreated control (T_9). *Trianthema portulacastrum, Amaranthus viridis, Portulaca oleracea, Digera arvensis, Echinochloa crus-galli* and *Chloris barbata* were the dominant weed species in tomatoes during the first and second experiments. Glyphosate potassium salt 46% SL at 2750 g/ha had the lowest total weed biomass at 15 DAT, with 1.23 and 0.69 kg/ha, respectively, in both the experiments. Hand weeding twice at 20 and 40 DAT recorded minimum total weed biomass of 0.66, 0.00 and 6.86 kg/ha in winter 2021 and 1.27, 0.00 and 5.49 kg/ha in summer 2021, respectively at 30, 45 and 60 DAT. The maximum weed control efficiency was observed with glyphosate potassium salt 46% SL at 2750 g/ha during both the experiments at 15 DAT, with 93.79 and 89.38%, respectively. Hand weeding twice at 20 and 40 DAT produced the highest fruit yield of 30.3 t/ha during winter 2021, which was on par with glyphosate potassium salt 46% SL at 2750 g/ha, which produced 28.7 t/ha. During summer 2021, maximum fruit yield (31.2 t/ha) was recorded with hand weeding twice at 20 and 40 DAT. During *Rabi* 2021 (confirmatory experiment) the highest tomato yield (38.3 t/ha) was recorded in hand weeding twice at 20 and 40 DAT and it was on par with glyphosate potassium salt 46% SL at 2750 g/ha (34.4 t/ha). Pre-plant application of post-emergence glyphosate did not affect the succeeding blackgram germination at both the experimental locations.

Effect of herbicides applied with and without FYM for weed management in onion

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Onion (*Allium cepa* L.) belonging to the family Alliaceae is one of the most important bulbous vegetable crops of economic importance and widely cultivated all over the world, with particular distribution in the Asian continent and in Europe. It is highly export oriented crop and considered as dollar earner crop for the country. Weeds are of great menace as they interfere with production of crop and increased the cost of cultivation. The reduction in onion bulb yield has direct correlation with the intensity of weed presence in the field. Onion exhibits greater susceptibility to weed competition as compared to other crops due to their slow growth, small stature, shallow roots and lack of dense foliage. An experiment was conducted at AICRP-Weed Management farm, B. A. College of Agriculture, Anand Agricultural University, Anand to study the effect of herbicides applied with and without FYM for weed management in Onion (*Allium cepa* L.) during the year of 2014-15 and 2015-16 in *Rabi* season in loamy sand soil. The experiment consisted sixteen treatment combinations comprised of two levels of farm yard manure (FYM) treatments, *viz.*,M_0 (No FYM) and M_1 (FYM 10 t/ha) and eight weed management treatments, *viz.*, W_1: pre-transplant application (PT) of pendimethalin 1000 g/ha, W_2: post-transplant application (PoT) of pendimethalin 1000 g/ha at 3-4 days after transplanting onion (DATP), W_3: oxyflurofen 150 g/ha PT, W_4: oxyflurofen 150 g/ha PoT 4-5 leaf stage of weed *i.e.* 15-20 DATP), W_5: oxadiargyl 100 g/ha PT, W_6 : oxadiargyl 100 g/ha PoT at 15-20 DATP, W_7: hand weeding (HW) twice at 20 and 40 DATP, W_8 :weedy check, which were tested in factorial randomized block design with four replications. Significantly the lowest weed density and biomass of monocot and dicot weeds were recorded with no FYM as compared to application of FYM 10 t/ha at 30 and 60 DATP and at harvest during both the years. Significantly the highest bulb yield was recorded with the incorporation of FYM 10 t/ha during both the years. Significantly lower number of total weeds and higher bulb yield were recorded with HW twice at 20 and 40 DATP followed by pendimethalin 1000 g/ha as PT or PoT. Application of pendimethalin 1000 g/ha had no residual effect on succeeding sensitive crop, *viz.* maize, pearl millet and greengram.

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Weed management strategy for onion nursery

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Onion (*Allium cepa* L.) crop is mostly grown by the transplanting of seedling raised in the nursery. Onion nursery is heavily infested by the weeds due to its slow growth, non branching habit and very less and erect plant canopy. Due to non-availability of timely labour, weeds are not controlled at the proper stage of the crop resulted in production of unhealthy seedlings. Hence, the use of herbicides is one of the options left with the farmers to eliminate crop weed competition at early growth stage in onion nursery. Weed management in onion nursery using herbicides is helpful to raise weed free nursery. Hence, the present experiment was conducted at AICRP on Weed Management Farm, Anand Agricultural University, Anand during *Rabi* season of the year 2020-21 on loamy sand soil with twelve treatments and three replications to manage complex weed flora and obtained healthy onion seedlings for transplanting. Experimental field was infested with complex weed flora with the overall dominance of dicot weed (90.7%) during the experimentation period. Major weed species observed in the experimental field were *Eleusine indica* (3.93%), *Digitaria sanguinalis* (1.97%), *Setaria glauca* (1.72%) and *Dactyloctenium aegyptium* (0.98%) as monocot weed, while *Chenopodium album* (63.1%), *Melilotus indica* (12.8%), *Chenopodium murale* (11.8%) and *Trianthema monogyna* (2.21%) as dicot weed. Significantly lower density and dry biomass of monocot and dicot weeds at 45 days after seeding (DAS) as well as higher number of transplantable seedling (733/m^2) was recorded under hand weeding twice carried out at 15 and 30 DAS, and was at par with post-emergence application (at 15-20 DAS) of either oxyfluorfen 80 g/ha (662/m^2) and propaquizafop 5% + oxyfluorfen 12% w/w EC (PM) 43.75+105 g/ha (618/m^2) in onion nursery which also fetched higher gross return, net return and benefit cost ratio.

Effect of weed management and phosphorus fertilization practices on productivity of cowpea

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A field experiment was conducted during *Kharif* 2019 at Rajasthan College of Agriculture, Udaipur consisting 18 treatment combinations with 6 weed management treatments and 3 phosphorus doses. These treatments combinations were tested using factorial RBD with 3 replications. The weed management treatments effectively reduced crop-weed interference compared to weedy check. Pre-emergence p aplication (PE) of pendimethalin 1000 g/ha followed by (*fb*) hand weeding (HW) at 15-20 days after seeding (DAS) significantly reduced density and biomass of monocot, dicot and total weeds up to 25 DAS compared to other treatments, except weed free treatment. Whereas, from 25 DAS onwards and up to harvest pendimethalin 750 g/ha PE *fb* imazethapyr + imazamox 33.75 g/ha as post-emergence application (PoE) significantly reduced all these parameters compared to other treatments, except weed free treatment. Maximum weed control efficiency (WCE) of total weeds at 25 DAS was recorded with pendimethalin 1000 g/ha PE *fb* HW at 15-20 DAS (60.82%); at 50 DAS and harvest was recorded with pendimethalin 750 g/ha PE *fb* imazethapyr + imazamox 33.75 g/ha PoE (79.23 and 76.90%, respectively), except weed free treatment. The minimum weed index at harvest was observed with pendimethalin 750 g/ha PE *fb* imazethapyr + imazamox 33.75 g/ha PoE (4.35%) followed by pendimethalin 1000 g/ha PE along with HW at 15-20 DAS (4.91%). Weed free treatment recorded the highest seed and haulm yield (0.77 and 2.09 t/ha, respectively) which was statistically equivalence with pendimethalin 750 g/ha PE *fb* imazethapyr + imazamox 33.75 g/ha PoE (0.736 and 1.99 t/ha, respectively) and pendimethalin 1000 g/ha PE *fb* HW at 15-20 DAS (0.73 and 1.98 t/ha, respectively). The highest net returns and B:C ratio (₹ 39,737/ ha and 2.04) was obtained with pendimethalin 750 g/ha PE *fb* imazethapyr + imazamox 33.75 g/ha PoE. At 25 DAS and harvest application of 50 kg P_2O_5/ha resulted in the highest total weed biomass (0.407 and 1.06 t/ha, respectively) which was statistically at par with application of 40 kg P/ha (0.355 and 1.0 t/ha, respectively). Enhanced seed yield, haulm yield, net returns and B:C ratio of cowpea was obtained with application of 40 kg P/ha over 30 kg P/ha and further addition of phosphorus from 40 to 50 kg P/ha failed to attain any significant enhancement in these parameters. The productivity of the crop in Zone-IV (a) of Rajasthan is low and far below than its potential yield, possibly due to inadequate weed management as well as poor nutrition especially phosphorus fertilization. Therefore, adoption of proper weed management practices and application of fertilizer in sufficient amount would improve productivity of cowpea.

Efficacy of herbicides for weed management in summer cowpea

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Cowpea is one of the important legume but due to severe infestation of weeds the potential yield is generally not realized. Hence, there is a need to find out prominent pre- or post-emergence herbicide either alone or in combination with cultural practices for timely control of weeds. Here, the field experiment was carried out during summer season of the year 2019 at College farm, Navsari Agricultural University, Navsari (Gujarat) with a view to study the efficacy of herbicides for weed management in cowpea (*Vigna unguiculata* L.). The experiment was laid out in randomized block design with four replications which comprised nine weed management treatments, *viz.* weedy check (W_1), weed free by hand weeding (HW) twice at 20 and 40 days after seeding (DAS) (W_2), pendimethalin 750 g/ha pre-emergence application (PE) (W_3), imazethapyr 60 g/ha at 20 DAS (W_4), quizalofop-ethyl 40 g/ha at 20 DAS (W_5), pendimethalin 750 g/ha PE *fb* HW at 30 DAS (W_6), pendimethalin 750 g/ha PE *fb* imazethapyr 60 g/ha at 30 DAS (W_7), pendimethalin 750 g/ha PE *fb* quizalofop-ethyl 40 g/ha at 30 DAS (W_8), stale seed bed (destroy one flush of weeds) (W_9). Significantly higher plant height at 60 DAS and harvest, no. of branches at 60 DAS and harvest, no. of pods per plant, no. of seeds per pod, seed (1.35 t/ha) and stover yield (2.04 t/ha) were found superior with pendimethalin 750 g/ha PE *fb* HW at 30 DAS, being statistically at par with weed free by HW twice at 20 and 40 DAS and pendimethalin 750 g/ha PE *fb* imazethapyr 60 g/ha at 30 DAS. The cowpea seed yield was increased by 3.35-fold in pendimethalin 750 g/ha PE *fb* HW at 30 DAS over weedy check. Further looking towards effect on weed, biomass of weeds at 40 DAS found significantly lower with pendimethalin 750 g/ha PE *fb* HW at 30 DAS (19.4 g/m^2). Furthermore, at harvest, weed free treatment recorded significantly lower biomass of weeds (251 kg/ha), which was statistically at par with pendimethalin 750 g/ha PE *fb* imazethapyr 60 g/ha at 30 DAS and pendimethalin 750 g/ha PE *fb* HW at 30 DAS. The highest weed control efficiency (69.07%) and the lowest weed index (1.40%) were registered under weed free treatment. Among different weed management practices, pendimethalin 750 g/ha PE *fb* imazethapyr 60 g/ha at 30 DAS recorded maximum BC ratio (3.14). Overall, pendimethalin 750 g/ha PE *fb* HW at 30 DAS showed promising and profitable response of cowpea crop. However, in view of the increasing wages and crisis of labour at critical periods, pendimethalin 750 g/ha PE *fb* imazethapyr 60 g/ha at 30 DAS can be opted as it was equally effective and remunerative weed management option for summer cowpea.

TECHNICAL SESSION 4

Herbicide residues, monitoring, mitigation and effect on non-target organisms in weed management

Screening and monitoring of herbicide residues in rice ecosystem by a new thin layer chromatography (TLC) method

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Rice (*Oryza sativa* L.) is a main food for more than 50% population of the world. Approximately 35 to 80% rice yield losses have been reported worldwide due to weed competition in rice crop. Management of diverse weed flora which consist of grasses, sedges and broad-leaved weeds in rice is a major challenge and, in most instances, single application of either a pre- or post-emergence herbicide cannot control varied range of weeds. Therefore, several pre-mix herbicide combination products such as, triafamone +ethoxysulfuron, Metsulfuron-methyl +chlorimuron-ethyl, cyhalofop-butyl +penoxsulam, *etc*. are being applied to control complex weed flora in rice fields all over the world. Presence of herbicide residues in the soil and environment may not only damage the sensitive succeeding crops but also adversely affect human and animal health due to bioaccumulation of residues in crop produce. Hence continuous monitoring and development of new methods for analysis of herbicide residues in the soil and agricultural commodity is essential. For development of any new analytical method, it should be able to determine multicomponent pesticide mixtures simultaneously, with good reproducibility and a high recovery. Thin layer chromatography (TLC) can easily be used for herbicide residue detection in complex matrices with minimal matrix modification. Through, with the advent of gas and liquid chromatography, the use of TLC for the quantitative determination of pesticide residues is becoming less popular. However, for screening and identification purposes, TLC methods are still being used in many laboratories; because for these methods sample clean-up is either simple or not required. So far, there is no TLC-UV method available for simultaneous extraction and detection of herbicides namely cyhalofop-p-butyl, ethoxysulfuron, penoxsulam, pyrazosulfuron-ethyl, pretilachlor, and triafamone in rice ecosystem. Therefore, a new TLC analysis method was developed for the simultaneous analysis of rice herbicides applied in rice crop for weed control. Among various TLC solvents evaluated, the TLC-UV technique with silica gel plates, using solvent system consisted of ethyl acetate, hexane, benzene, methanol was found to be effective in separation of rice herbicides with Rf in the range of 0.21 to 0.91. The impurities and matrix effects from samples were found to be minimal and did not limit with the identification of targeted herbicides. The method developed is found to be suitable to detect residues of these herbicides in soil, rice grains and straw samples in a concentration as minimum as 0.01 mg/Kg. This method can also be explored for determination of a wide range of other herbicide residues used in rice fields as well as several other herbicides of various similar chemical classes from different matrix. This study evidenced that this method may be used in routine analysis of these herbicides with low limit of detection value and good analytical precision.

Long-term effect of conservation agriculture and weed management practices on soil carbon fractions in a vertisol

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Adoption of conservation agriculture (CA), with principles of minimum soil disturbance (zero/ no-tillage), retention of crop residues and crop diversification, had been reported to show positive effects on soil carbon dynamics, sequestration and overall soil quality.However, some studies showed that zero-tillage (ZT) accumulates soil organic carbon over conventional tillage (CT), but only in surface layer not in the whole soil profile. In view of this, a study was carried out to quantify the long-term impact of different CA practices and weed control measures on built-up of carbon pools in a Vertisol. Surface (0-15 cm) and sub-surface (15-50 cm) soil samples were collected after eight years of a long-term field trial consisting of five crop establishment methods (T1: conventionally tilled (CT) direct-seeded rice (DSR) (CT DSR) – CT wheat – zero tillage (ZT) greengram; T2: CT DSR – CT wheat – ZT greengram + Recycling of preceding crop residue; T3: ZT DSR – ZT wheat – ZT greengram; T4: ZT DSR – ZT wheat – ZT greengram + Recycling of preceding crop residue;T5: puddled transplanted rice (TPR) - CT wheat) as main-plot treatments and three weed control measures (W1: un-weeded control;W2: repeated application of recommended herbicides;W3: herbicide rotation) as sub-plot treatments.Samples were processed and analysed for different fractions (very labile, labile, less labile and non-labile) of organic carbon.In the surface layer, the highest levels of very labile, labile, less labile and non-labile fractions of organic carbon were recorded under the crop establishment method of ZT DSR – ZT wheat – ZT greengram + Recycling of preceding crop residue (T4).This treatment also showed highest levels of labile and non-labile carbon fractions in sub-surface soil layer.The highest level of very labile carbon fraction in sub-surface soil layer was recorded under crop establishment method of CT DSR – CT wheat – ZT greengram + recycling of preceding crop residue (T2), and it was statistically similar to T4. The highest level of total soil organic carbon in both surface and sub-surface layers was recorded with T4. It was concluded that conservation tillage along with retention of crop residue was superior over conventional tillage (CT and TPR) practices in terms of built-up of soil organic carbon pools. Among the weed control practices, herbicide rotation treatment showed lowest levels of all the carbon fractions in surface soil. Similar trend was also noticed in sub-surface soil. However, no significant interaction effect between weed management practices and crop establishment methods was recorded in terms of soil organic carbon pools.

Harvest time residue of clomazone in soybean

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Soybean (*Glycine max* L.) is the most significant seed legume on the planet, providing approximately 48.2-60% of worldwide edible oil and two-thirds of global protein concentrate for animal nutrition. Soybean by-products, such as straw and shell, provide significant nutritional value to some animals and poultry. Alternatively, weeds would contend with soybeans for nutrients throughout the growing season, lowering soybean quality and production. Clomazone is being used to manage grasses and broad-leaved weeds. Clomazone is [2-(2-chlorobenzyl)-4,4-dimethyl-1,2- oxazolidin-3-one] belongs to an isoxazolidinone herbicide. It is a selective herbicide used for the pre-emergence control of a variety of grasses and broad-leaved weeds. Clomazone inhibits synthesis of chlorophyll and carotenoids in plants. It is absorbed by plants through the roots from the soil and by shoots which is then translocated in the xylem and diffuses within leaves. It does not move downward in plants or from leaf to leaf. The objective of this study was to evaluate the dynamics of herbicides clomazone applied on the soybean harvest time residue. Central Insecticide Board has registered this herbicide for soybean, sugarcane and transplanted rice. There is need to evaluate alternate pre-emergence herbicides for broad-spectrum weed control in soybean and their residual effect on succeeding rotational crops. The present experiment was carried out at Norman E. Borlaug (NEB) Crop Research Centre, G. B. Pant University of Agriculture, Pantnagar, Uttarakhand. The trial was conducted in a Randomized Block Design on soybean (variety of soybean PS-24) with two treatments, includes single foliar pre-emergence application of clomazone at standard and double dose i.e., 2000 and 4000 mL/ha at 3 day of sowing weed. Suitability of the extraction method for clomazone in soybean was worked out following recovery study at the limit of quantitation (LOQ), 5 X LOQ and 10 X LOQ *i.e.,* 0.05, 0.25 and 0.5 mg/kg for in five replications. Recoveries of clomazone were found in the acceptable range (70-120%) showing suitability of the extraction method. The overall mean recovery of clomazone at three different levels (0.05, 0.25 and 0.50 ppm) ranged 86.78 to 97.55, 88.09 to 102.82, 91.63 to 103.59 and 97.30 to 104.63% and 89.48 to 99.88% for grain, oil, cake and soil, respectively. Soybean grain, oil, cake and soil samples were collected at 116 days after application (at the time of harvest). The samples were extracted (QuEChERS method for pesticide residue analysis) and analysed on ABScix make LC-MS/MS, UPLC, API-3200. The results showed that the residues in soybean grain, oil, cake and soil were found below determination level (0.05 µg/g) at the time of harvest. The present data can be used for establishing MRL for this herbicide.

Dissipation of triafamone+ethoxysulfuron in soil under direct seeded and transplanted rice field

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Triafamone and ethoxysulfuron are selective herbicides belonging to sulfoamide and sulfonylurea group of herbicides used to combat broadleaf and sedge weeds. Under aerobic conditions, triafamone degrades rapidly with half-lives of 11 days while for ethoxysulfuron half-life values varied from 9.38-21.54 days. A thorough understanding of degradation behavior of triafamone+ethoxysulfuron under different scenarios is essential to understand the best use of herbicides. Commercial pre-mix formulation of triafamone (20%) and ethoxysulfuron (10%) was applied in field at recommended and double the recommended dose (67.5 and 135 g/ha) to direct seeded rice (DSR) and puddled transplanted rice (PTR)fields. The soil samples were drawn randomly from 0-15 cm depth using a tube auger from 6-7 spots in each plot at different time intervals i.e., 0 (4 hours), 1, 3, 5, 7, 10, 15, 30, 45, 60 days after application (DAA) of herbicides and at the harvest of crop from each of the treated and control plots. Rice samples were collected at harvest. Residues of triafamone and ethoxysulfuron in soil and crop produce were extracted using ultrasonic assisted extraction from soil and rice grain and liquid solid extraction from rice straw and quantified using HPLC.Limit of detection and limit of quantification were 0.008 and 0.0026 ìg/g, respectively. The mean percent recoveries of herbicides varied from 98.1 to 102.3, 85.6 to 89.8 and 75.2 to 79.5% in soil, rice grain and straw, respectively. The initial residues (3 h) after application of herbicides ranged from 0.0197 to 0.0398 and 0.0257 to 0.0435 ìg/g under TPR and DSR, respectively. With passage of time, the residues decreased and degradation of triafamone and ethoxysulfuron followed first order kinetics. Under DSR conditions, the dissipation was comparatively slow than PTR. The residues of triafamone and ethoxysulfuron were below detectable limit (BDL) in soil samples collected 30 and 60 DAA of herbicide at 67.5 and 135 g/ha in PTR while in DSR residues were BDL in soil samples collected 60 and 90 DAA of herbicide at 67.5 and 135 g/ha. Residues were below detectable limit (BDL <0.08 µg/g) in soil, rice grain and straw at harvest. In DSR, DT_{50} of triafamone and ethoxysulfuron ranged from 16.87 to 21.23 and 12.83 to 20.72 days, respectively at studied application rates. However, in PTR, we observed DT_{50} ranged from 11.08 to 14.67 and 9.62 to 18.30 days for triafamone and ethoxysulfuron, respectively. Dissipation was faster in PTR as compared to DSR and DT_{50} increased with increase in application rate of triafamone and ethoxysulfuron.

Degradation of mesosulfuron methyl + iodosulfuron methyl and their transformation products in soil

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Mesosulfuron methyl and iodosulfuron methyl are sulfonylurea herbicides used to combat weeds in wheat crop. These are moderately adsorbed to soil (K_{Fads}: 0.24-3.71 mL g^{-1} (mesosulfuron methyl) and 0.12-2.47 mL g^{-1} (iodosulfuron methyl)) and have low to moderate persistence in soil. The extensive and excessive use of these herbicide along with environmental impact has raised concern on the fate of these herbicide in soil. Therefore, it is essential to understand degradation kinetics of mesosulfuron methyl + iodosulfuron methyl in soils of Punjab. Mesosulfuron methyl and iodosulfuron methyl were extracted using ultrasound assisted extraction method. Pots with 500 g soil (loam 1, loamy sand, loam 2, sandy loam and clay loam) were treated with mesosulfuron methyl + iodosulfuron methyl (3.6 WDG) at an application rate of 14.4, 28.8, 43.2 and 57.6 g/ha under field capacity moisture conditions at 5±2ºC. A sample (20 g) was collected from each pot for the detection of residues of herbicides at 0, 3, 5, 7, 10, 15, 21, 30, 45, 60, 90, 120 and 150 days after application (DAA) of herbicide and quantified using HPLC. Dissipation followed first order kinetics with $R^2 > 0.99$. The rate of degradation was dependent on application rate of herbicides and soil type. DT_{50} for mesosulfuron methyl in studied soils varied from 10.72 to 22.47, 15.03 to 24.06, 18.06 to 29.44, 8.71 to 18.72 and 32.24 to 47.08 days in loamy sand, sandy loam, clay loam soil, loam 1 and loam 2 soil whereas it varied from 7.45 to 12.83, 8.50 to 15.92, 10.10 to 20.37, 7.16 to 10.77 and 18.07 to 38.24 days for iodosulfuron methyl. Metabolites of mesosulfuron methyl, *viz.* 4,6-dimethoxypyrimidine-2-yl-urea (M4), 2-amino-4,6-dimethoxypyrimidine (M5) and metabolites of iodosulfuron methyl, *viz.* metsulfuron methyl (I1), methyl-2-amino-sulfonyl benzoate (I2), 4-methoxy-6-methyl-1,3,5-triazine-2-amine (I3) and saccharin (I4) were detected in the studied soils. In addition, M1 and M2 were also detected and same could not be confirmed due to non-availability of their analytical standard. Appearance and disappearance of metabolites corroborated well with the results of dissipation of parent molecule. In soils in which dissipation of parent molecule occur slowly, the appearance and persistence of metabolites also occurred slowly and vice-versa which shows that similar mechanism was involved in the dissipation of parent molecules and their metabolites. DT_{50} increased with increase in application rate of herbicides. Dissipation was fastest in loam 1 soil as compared to other alkaline soils. Among both the herbicides, the half-lives for mesosulfuron methyl were comparatively longer than that of iodosulfuron methyl in studied soil indicating that mesosulfuron methyl was more persistent in the soil. Amongst different metabolites, M4 was more persistent followed by M2, M1, M5, I3, I4, I1 and I2.

Degradation of pyroxasulfone in soils of Punjab

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Pyroxasulfone is a pyrazole-based herbicide used in maize and wheat for the control of grass and broadleaf weed. It restrains shoot lengthening of vulnerable seedling plants by inhibiting the biosynthesis of extremely long-chain fatty acid. It has moderate to high persistent in soils depending upon physiochemical properties of soil, agronomics practices and experimental conditions. The present study evaluates degradation of pyroxasulfone in soils of Punjab for the best use of herbicides and protection of environment and human health. Air dried and sieved loamy sand, sandy loam and clay loam soil was added into plastic pots and saturated using distilled water. Following equilibration period, commercial formulation of pyroxasulfone was applied at the rate of 127.5 and 255 g/ha and the contents were thoroughly mixed and incubated. Control samples were also incubated under identical conditions. The soil samples (10 g) from treated and control pots were collected at 0, 1, 5, 10, 15, 30, 45, 60 and 90 days after treatment and pyroxasulfone was extracted and quantified using HPLC. Limit of detection and limit of quantification were 0.0026 µg/g and 0.008 µg/g, respectively. The mean percent recoveries of studied herbicides at fortification levels of 0.5, 0.1 and 0.008 µg/g were in acceptable range of 87.8 to 100.1%. Residues of pyroxasulfone were not detected in control soils incubated under same conditions. The initial residues at 3 hours after herbicide application ranged from 0.0676 ± 0.006 to 0.0844 ± 0.008, 0.0738 ± 0.002 to 0.0932 ± 0.005 and 0.0834 ± 0.0009 to 0.1023 ± 0.003 µg/g in loamy sand, sandy loam and clay loam, respectively at studied application rates. Residues were below detectable limit (BDL) (< 0.008 µg/g) at 30 to 90, 45 to 90 and 60 to 120 DAA of herbicide in loamy sand, sandy loam and clay loam at studied application rates of pyroxasulfone in soil. Half-life varied from 6.46 to 9.01, 8.91 to 12.37 and 12.50 to 16.87 days in loamy sand, sandy loam and clay loam soil. Physiochemical properties of soil and application rate of herbicides influence the rate of degradation of pyroxasulfone and degradation was fastest in loamy sand soil followed by sandy loam and clay loam soil.

Effect of herbicide on soil biochemical properties under varying level of crop, nutrient and herbicide dose in wheat under vertisols of Central India

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Research from the past highlighted that herbicide application in the crop field directly or indirectly influences various soil biochemical activities like microbial biomass carbon (MBC) and soil enzymatic activities like dehydrogenase (DHA), urease (URE), acid phosphatase (ACDP) and alkaline phosphatase (ALKP) activities which are linked with carbon and nutrient cycling; mostly of them confined to lab incubation study using very high dose (5X, 7.5X and 10X dose, X= recommended dose) of herbicide application and very few had been reported under actual field condition. Further it was reported that application of soil amendmends like organic matter, nutrients and presence crop rhizosphere greatly modifies the negative impact of herbicides at initial periods. Keeping all these in view, an experiment had been laid out in factorial randomized block design (FRBD) using 3 factors namely, factor A- crop (C1) vs non crop (C0) (to isolate rhizosphere effect), factor B – soil amendments i.e, control (F0, receiving no external inputs), RDF (F1, recommended dose of fertilizer, 120-60-40 kg NPK/ha), RDF + 3 t crop residue (F2) and factor C – herbicide dose, such as, no herbicide (H0), field recommended dose (H1, 1X, 4 g a i / ha) and double recommended dose (H2, 2X, 8 g a i /ha). Soil samples form 0-15 cm were collected from crop plot (rhizosphere soil sample) and non-crop plot (non-rhizosphere soil) at different days intervals, *viz.* 1,15,30,45 and 60 days after herbicide application (DAHA). Results highlighted that, there was deleterious effect of herbicide at 2X dose in soil MBC, dehydrogenase, acid phosphatase and acid phosphates activities immediately after herbicide application (1 and 15 DAHA). This immediate suppression effect was more visible in non crop plots (absence of rhizosphere effect) and plots receiving no external inputs. Application of soil amendments such as RDF and RDF + crop residue and presence of crop minimized the suppression effect of herbicides even at 2X dose. At later sampling time, this initial suppression effect of herbicides on MBC and other soil enzymes gradually disappeared and showed stimulation effect. At 60 DAHA, we observed that application of herbicide had no negative effect on soil biological parameters. Therefore, we can conclude that, that under field condition herbicide had no negative effect on soil biological health if applied at field recommended dose and good crop management practices (balanced fertilization and crop residue recycling) will curb the ill effect of herbicides on soil functioning.

Degradation and persistence of herbicides in soil and consequent residues in rice- rice cropping system

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Field experiments were conducted in wetland, Tamil Nadu Agricultural University, Coimbatore during *Rabi* 2019-20 and *Kharif* 2020 to study the degradation and persistence of herbicides in soil and consequent residues in transplanted rice- rice cropping system. The experimental soil was clay loam in texture with a pH of 7.74, EC of 0.52 dS/m and organic carbon content of 0.63% and low, medium and high in available NPK status. The treatments comprised of low dose herbicides, *viz.*, pyrazosulfuron-ethyl, bispyribac-sodium, penoxulum**,** pretilachlor, bensulfuron-methyl and cyhalofop-p-butyl in different combinations. Soil samples were collected at 0,1,3,5,10,15,30,45 and 60 days after herbicide application (DAHA) during *Rabi* 2019-20, up to 45 days during *Kharif* 2020 from the herbicides applied plots and were subjected to respective residue analysis to find out the persistence and residues in soil using HPLC equipped with PDA detector. The dissipation of all the molecules was found to follow first order reaction kinetics (R^2>0.90) in both the seasons with the half life of 7.66-9.51 days for pyrazosulfuron ethyl, 9.42-9.72 days for bensulfuron- methyl, and 6.48-7.8 days for bispyribac-sodium, 5.03 - 5.67 days for cyhalofop-butyl,6.79 days for penoxulum during *Rabi* 2019-20. The half life of 7.54-8.43 days for pyrazosulfuron-ethyl, 4.10 days for bispyribac-sodium,5.67 days for cyhalofop-butyl, 6.74 days for penoxulum during *Kharif* 2020. More than 80% of herbicides were dissipated from the soil within 15 DAHA in both the seasons. Similarly plant grain and straw samples were also analysed for their residues using the standardized extraction, cleanup and determination using HPLC equipped with PDA detector. The residues of all the herbicides in grain and straw from different plots were below 0.01 mg/kg in both the seasons. Pre-emergence (PE) and post-emergence allication (PoE of herbicides reduced the soil enzyme activities upto 15 DAHA and started increasing from 30th DAHA and got reduced at harvest. Among the herbicide treatments, bensulfuron- methyl+Pretilachor PE followed by (*fb*) hand weeding (HW) and bensulfuron-methyl+ pretilachor PE *fb* bispyribac-sodium PoE recorded maximum soil enzyme activities. Lower dehydrognease activity and higher urease activity was observed with pyrasosulfuron-ethyl PE compared to other herbicides. However, higher dehydrogenase activity was recorded with pyrazosulfuron-ethyl PE *fb* bispyribac-sodium PoE than other herbicide combinations during *Rabi* 2019-20 During *Kharif* 2020, higher soil enzyme activities, *viz.*, alkaline phosphatase, dehydrogenase and urease were recorded with pyrasosulfuron-ethyl PE *fb* bispyribac- sodium PoE. Lower dehydrognease activity and higher urease activity were observed with pyrasosulfuron-ethyl compared to other herbicides. However, higher dehydrogenase activity was recorded with pyrasosulfuron-ethyl PE *fb* bispyribac-sodium PoE compared to other herbicides. Higher microbial biomass carbon was observed with pyrasosulfuron- ethyl PE *fb* bispyribac-sodium PoE in both the seasons.

TECHNICAL SESSION 5

Non-chemical weed management including biological control

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Expanding invasion of invasive alien aquatic weed *Salvinia molesta* in other parts of India and its successful biological control in Central India

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The *Salvinia molesta*, commonly known as “water fern” is an aggressive and a fast-growing invasive alien aquatic weed of the South-Eastern Brazil origin. This species is widespread in 20 countries of Africa continent, Australia, New Zealand, the Southern USA, the Indian subcontinent, South-East Asia, and some Pacific islands. In view of its seriousness, it has also been added in the list of the World’s 100 most invasive weeds of the world. The weed affects irrigation, hydroelectric generation, water availability and navigation choking rivers, canals, lagoons besides drastic reduction in fish production. It is also capable of reducing rice yields by competing for available nutrients. In India, *S. molesta* was first seen in 1950s in Veli Lake of Thiruvananthapuram in Kerala which invaded all the water bodies throughout the state by 1964 also many reservoirs in other states in Southourn part of India besides its spread in Odisha, and stray occurrence in one of the reservoirs in Uttarakhand. In central part of India, first time during a survey, severe infestation of *S. molesta* was noticed in Satpura reservoir at Sarni in district Betul of Madhya Pradesh in more than 70% out of total 1100-hectare area of reservoir. The observed severe infestation of *S. molesta* in Central part of India adjoining to Northern part of India prompted the author to undertake a study to delineate its further spread in other parts of India out of its earlier well documented habitat and to explore the possibilities of its biological control in this region of India by the bioagent *Cyrtobagous salviniae* (Calder and Sands), which has provided an effective and sustainable solution in Kerala and other regions of introduction. However, its effect is yet to be studied in Central and Northern parts of India, with large temperature fluctuations. The severe occurrence of *S. molesta* during surveys were recorded in 09, 12, 04 and 01 water bodies in Madhya Pradesh, Maharashtra, Chhattisgarh and Haryana, respectively. This spread in different parts of India having wide climatic range clearly reflects its increasing invasion in India. A pond of about 20 hectares was selected in the village Padua of Katni district in Madhya Pradesh for demonstration of biological control using bioagent *Cyrtobagous salviniae*. This pond was severely affected by the *S. molesta* since 2015 and all the efforts by villagers were proved futile to remove the weed from the ponds due to its aggressive multiplication. About 2000 adult weevils collected from the Kerala were released in the mid of the pond in December, 2019. There was no visible impact of bioagent by the June, 2020, however 50, 80 and 100% of water surface appeared during September, 2020, November, 2020 and June 2021, after 8, 11 and 18 months of release of weevil, respectively. It was first successful demonstration of biological control of *S. molesta* by *C. salviniae* in central part of India out of its known habitat of Kerala and Karnataka. Observing this biological control success, bioagents have been released in different 15 water bodies comprising of about 3400 hectares areas.

Effect of weed management practices in organic production on weed control, yield and economics of soybean-chickpea sequence under irrigated condition

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The field experiment conducted in *Kharif* and *Rabi* season from 2017-18 to 2021-22 for five successive years at experimental farm of AICRP on Integrated Farming System, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S) India. Entitled with ”Evaluation of weed management practices under organic production on Yield and economicsin soybean-chickpea sequence.” The experiment was laid down in randomized block design with three replications. The present investigation consists of ten organic weed management treatments. The weed management treatments were: two hand weedings (HW) at 20-25 and 45-50 DAS, one hoeing 20-25 DAS + one HW at 45-50 DAS, soybean + sunhemp incorporation after 35-40 DAS in *Kharif* season and chickpea + safflower (2:1) in *Rabi* season, stale seed bed + reduced spacing + mulching with wheat straw (2 t/ ha) + one HW at 25 DAS, soil mulch at the time of sowing + one hand pulling at 25 DAS, incorporation of neem cake 1.5 t/ha 15 days before sowing + one HW at 25 DAS, soil solarization with 25 ì polythene mulch during summer + one HW at 25 DAS, mulching with straw, weed free and weedy check., with the objectives to evaluate the cultural and mechanical weed management practices on growth and yield under organic production system, to find out economically viable practically applicable alternative to hand weeding for organic weed management. Among these treatments weed free recorded higher SEY (5455 kg/ha), Gross monetary returns (192813 ₹/ ha), Net Monetary returns (93020 ₹/ha), system profitability (255 ₹/ha/day) and system productivity (19.98 kg/ha/day) and statistically at par with treatment of Stale seed bed + reduced spacing + 2 tonne ofstraw + One hand weeding at 25 DAS. In case of Benefit:Cost ratio treatment Stale seed bed + reduced spacing + 2 tonne ofstraw + One hand weeding at 25 DAS recorded 1.96B:C ratio in Soybean-chickpea cropping sequence fallowed by weed free treatment (1.93). lowest weed density (No/m^2), weed biomass (g/m^2) and higher weed control efficiency in soybean and chickpea crop at 40 DAS recorded by Stale seed bed + reduced spacing + 2 tonne ofstraw + One hand weeding at 25 DAS. and treatment Stale seed bed + reduced spacing + 2 tonne ofstraw + One hand weeding at 25 DAS found economically viable practically applicable alternative to yield, economics and weed check in organic weed management.

Non-chemical weed and nutrient management in brinjal

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The study was on development of organic farming package for brinjal (*Solanum melongena* L.), It was conducted during *Kharif* season of 2017 and 2018 at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India. The experiment was laid out in strip plot design with three replications. The main plot treatments were applied to brinjal comprised of non-chemical weed control, *viz. Gliricidia* leaf mulching 5 / ha, biodegradable mulch (soybean straw) 5 t/ha, mechanical (hoeing) intercultivation and pulling of weeds, control - weedy check, weed free (hand weedings with 15 days interval). The sub plot treatments comprised of seven organic sources treatments, *viz.*, 100% recommended dose of nitrogen (RDN) using farm yard manure (FYM) with biofertilizers, 100% RDN through vermicompost with biofertilizers, 100% RDN using neem cake with biofertilizers, 50% RDN each using FYM and vermicompost with biofertilizers, 50% RDN each using FYM and neem cake with biofertilizers, 50% RDN each using vermicompost and neem cake with biofertilizers, 1/3 N each using FYM, vermicompost and neem cake with biofertilizers. The weed flora and its composition of monocot weeds, *viz. Cynodon dactylon, Dagitaria sanguinalis, Dinebra retroflexa, Brachiara erusiformis, Cyperus rotundus*and dicot weeds, *viz. Amaranthus polygamous, Amaranthus viridis, Parthenium hysteriphorus, Convolvulus arvensis, Euphorbia hirta.* The total weeds species increased as brinjal crop growth advanced from 30 days after transplanting to 120 days after transplanting during both the years. Monocot and dicot weed intensity, categorywise weed density, *viz.,* grasses, broad-leaved weeds, sedges and total dry biomass of weeds was significantly at lower and weed control efficiency was at higher magnitude as well as weed index was significantly lower in weed free followed by mechanical (hoeing) intercultivation and pulling of weeds at 20 days interval from 20 to 80 days after transplanting of brinjal crop during both the years of experimentation. The growth parameters, *viz.,* plant height, number of primary branches/ plant, number of secondary branches/plant, total number of branches plant^{-1}, number of leaves plant$^{/}$, leaf area plant^{-1}, dry matter /plant, phenological parameters, *viz.,* days to first flower initiation, days to first picking, number of days from first flower initiation to first fruit of brinjaland the yield and yield attributes, *viz.*, number of fruits plant^{-1}, weight of fruits/ plant, equatorial and polar diameter of fruits, fruit shape index, average weight of fruits, fruit yield significantly higher under the weed free followed by mechanical (hoeing) intercultivation and pulling of weeds at 20 days interval from 20 to 80 days after transplanting of brinjal and application of 50% RDN each through FYM and vermicompost with biofertilizers and it was at par 50% RDN each through FYM and neem cake with biofertilizers during both the years of experimentation.

Control of *Parthenium hysterophorus* for sustainable farming practices

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The currently needed sustainable agriculture necessitates the organic and natural means of managing weeds. The use of biocontrol agents (insects and fungal pathogens) and exploitation of competitive plants (allelopathy) are the most economic and practical ways of managing *Parthenium hysterophorus* L. (*Parthenium*) under organic and natural farming adoption. Various methods, for example, physical, chemical, bioherbicidal and integrated are being practiced to manage this weed around the globe. Manual uprooting of *Parthenium* before flowering and seed set is also an effective method. This invasive plant species is available in stocks around railway tracks, in bare lands, in agriculture fields, in orchards and forests. It has the potential to damage crops, industries, environment and public health. Its high germination ability throughout the year, enormous seed bank, rapid spread, colonization and extreme adaptability in a wide range of habitats are responsible for its widespread occurrence. *Parthenium* was reported to be one of the seven most dangerous weeds in the world. It has achieved a major weed status in India and other countries in the world within a relatively short period due to its fast multiplication, rapid growth and its ability to compete with other native flora. Competitive replacement of *Parthenium* can be achieved by planting plants like *Cassia sericea, C. tora, C. auriculata, Croton bonplandianum, Amaranthus spinosus, Tephrosia purpurea, Hyptis suaveolens, Sida spinosa* and *Mirabilis jalapa* which are capable of effectively suppressing *Parthenium* natural habitats. A study in India revealed that *Cassia sericea* reduces the growth of *Parthenium* by 70% and *Parthenium* population by 52.5%. Another study showed that aqueous extracts from *Imperata cylindrica, Desmostachya bipinnata, Otcantium annulatum* and *Sorghum halepense* markedly suppressed seedling growth and germination of *Parthenium*. In India, crop rotation using marigold (*Tagetes* spp.) during the rainy season, instead of the usual crop, was found effective in reducing *Parthenium* infestation in cultivated areas. This review aims to provide information about the management of *Parthenium*in in a sustainable manner.

Herbicidal activity of mustard essential oil against *Avena ludoviciana* and *Phalaris minor* Retz

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Weeds impact agriculture by competing with crops and reducing quantity and quality of agricultural products. Chemical herbicides are the most preferred methods of weed management. The recurrent, extensive use of chemical herbicides usually results in a development of herbicide resistance among weeds over time, in addition to the occurrence of negative environmental impacts. Natural products are a complex mixture of different compounds with high structural diversity and multiple mechanisms of action. Plant derived mustard essential Oils (EO) has been studied for antibacterial, antimicrobial, antifungal and insecticidal properties. Mustard EO has also been used in flavouring and food industry and is generally recognised as safe by Food and Drug Administration of the United States (Mustard EO contain the high amount of allyl isothiocyanate (97.62%). The current study aims to evaluated herbicidal potential of mustard EO against *Avena ludoviciana* and *Phalaris minor* Retz. (Resistant and Sensitive biotypes). Pots were filled with 500 g loamy sand soil. In each pot, surface sterilized 20 seeds of *A. ludoviciana* and *P. minor* (Resistant and Sensitive) were sown at a depth of 1-2mm. The pots were treated with mustard essential oil at concentration ranging from 0.1 to 1.0 wt%. The emulsions of these concentration were prepared by mixing them with 1.95 wt% of tween 80. A solution of tween 80 in distilled water served as control. After 15 days, root & shoot length and number of emerged seedlings were measured. Reduction in emergence and root & shoot length of studied weeds in response of EO was observed in concentration dependent manner. In comparison to control, significant reduction in germination% was found in treated pots.The germination of *A. ludoviciana* and *P. minor* resistant and sensitive biotypes was reduced by 62, 60 and 78% respectively at 0.3% of EO concentration. At 1.0% concentration of EO the germination of *A. ludoviciana* and *P. minor* resistant and sensitive was reduced by 95, 92 and 90% respectively. LC_{50} values were calculated from the dose- response inhibition curves of inhibition in germination of studied weeds under the influence of EO. EO with LC_{50} value of 0.161, 0.174 and 0.141 for *A. ludoviciana* and *P. minor* resistant and sensitive indicating that mustard EO was more toxic on *P. minor* sensitive by *A. ludoviciana* and *P. minor* resistant. This study concludes that mustard EO has the potential to be used as bioherbicide and can constitute an alternative option of weed control. Further studies to explore the potential of combination of mustard essential oil and seed meal to obtain similar higher and expected herbicidal activity at low concentrations of essential oil are in progress. Research is also required to test these materails at ground in real field situations in the context of cost-effectiveness.

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Intrusion of Parthenium and its eco-friendly management: The world most offensive weed

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Outlandish offensive plants such as *Parthenium hysterophorus* L. (Asteraceae), ever so often known as Parthenium, characterize serious encounters to biodiversity, agriculture, and the transmission of ecosystem, compensations the quality of rangelands in assaulted ecosystems. Parthenium alters the vegetation structure of recipient habitats by releasing allelochemicals that hinder the growth of simultaneous plants, resulting in monospecific stands of Parthenium. Various efforts such as chemical, mechanical and biological have been made for its prevention, eradication and control, but effectual in a minus figure. For that reason, the weed management policy needs to be turned nearer certain operative not related to chemical methods. Make into compost might be a useful substitute to recycle organic matter such as weed (leaves) from this species to a valuable substantial. The compost and vermicompost of this weed has been made using different methods with variety of organic wastes. Here, this approach is giving supplementary nutrients than simple farm yard manure from a waste. It can be prepared at low cost and it is also easy to prepare. It is a balanced bio-fertilizer. It provides us numerous paybacks by increasing the proficiency of production, dropping the use of chemical fertilizers, refining the soil structure and the furthermost imperative thing is that it is eco-friendly. Thus, it is beneficial for achieving the goal of sustainable agriculture.The target of control through the action of making practical and effective use can be attained through joint transference from one place to another, or an appearance of researcher discovery of the uses of the weed also could pay the way for indirect eradication of the weed at present. While *Parthenium hysterophorus* is heeded a weed its new uses are coming to the forefront. Nanomedicine biopesticide, green manure. potential agent for bio-remediation of toxic metals and dyes, herbicides, substance acted upon (as by an enzyme) very petty. Production and source of biogas are some of the recently determined something else in the future of Parthenium.

Organic weed management

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Weeds constitute a special class of pest which seriously limits the production of the major crops. These compete with the crops for all the inputs which are given for the crop growth and play a significant role in reducing the productivity of the crops. Weeds account for 33% loss in agriculture alone. Present agricultural system is productivity oriented and depends mainly on inorganic inputs to control weeds. Although herbicides provide promising rise in crop yield by efficient control of weeds, but unwise use of these synthetic herbicides could cause several ecological and health related issues. Restriction of synthetic herbicide use in organic agricultural systems increases the complexity of weed management leading organic farmers to cite weeds as the greatest barrier to organic production.

Approaches for Organic weed management-

Preventive measures

Cultural weed management

Mechanical weed management

Biological weed management

Chemical weed management (Organically approved)

Whatsapp Message Organic weed management is user friendly, non hazardous and environmentally safe and effective for sustainable crop production. It is concluded that physical weed control can only be successful where preventive and cultural weed management is applied to reduce weed emergence (*e.g.* through appropriate choice of crop rotation, tillage & cover crops) and improve crop competitive ability (*e.g*. through appropriate choice of crop genotype, sowing pattern and fertilization strategy). There is the problem of farmers' acceptability of these approaches because of perceived ineffectiveness and farmers inability to evaluate the negative impact of synthetic chemicals on the environment and human health. Organic weed management improves soil health as well as human health by reducing the risk of chemical residues.

Weed management through mulching: Boon for chickpea production

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Chickpea (*Cicer arietinum* L.) is most important *Rabi* pulse crop of India. It occupies first rank among pulses with 30% of acreage and 40% of total pulses production. It has more economic importance in India and besides its deep tap root system and nitrogen fixation by root nodules that regulate the functions of maintaining soil fertility and more fit in cropping system. Chickpea is poor competitor with weeds, because of its slow initial growth and less leaf area at early stage of growth. The invasive and noxious weed species is the main challenge for chickpea production. Weed is the major limiting factor in improving chickpea production as weeds cause more than 40% reduction in yield of chickpea (Ratram *et al.* 2011). The mulch is an effective measure to suppress the weeds at early stage as well as later stage of crop growth and reduces crop weed competition. Mulching is one of the ways to reduce weed infestation and also conserve soil moisture and enhance soil microbial activities and crop yield. Thus, a field experiment was conducted with an objective to study the effect of mulching on weed management and growth and yield of chickpea. Mulching treatment like, sugarcane trash mulch 5 t/ha and without mulch were tested in factorial randomized block design with three replications during 2021-22 in *Rabi season* at Navsari, Gujarat, India. The weed density and biomass were significantly reduced and maximum weed control efficiency (WCE) was observed with sugarcane trash mulching 5 t/ha. The The growth parameters of chickpea crop such as plant height, number of branches, crop growth rate and relative growth rate during 30-60, 60-90 DAS and 90 DAS to harvest and number of root nodules and dry weight of modules/plant at 30, 45 and 60 DAS increased significantly. The yield attributes, *viz.* pods/plant, test weight and seed as well as stover yields of chickpea also recorded significantly higher with sugarcane trash mulching over without mulching in chickpea crop. Soil microbial population like bacteria, fungi and actinomycetes were improved significantly with mulch treatment. Nutrients content and uptake also remarkably increased due to mulching in chickpea. The maximum net returns were recorded with sugarcane trash mulching treatment. Hence, mulching with sugarcane trash results in a significant increase of chickpea growth, yield with reduced weeds growth and helps to attain higher income in irrigated chickpea crop grown in *Rabi* season under South Gujarat condition.

Weed management in organic farming

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Organic agriculture is practiced in 187 countries, and 72.3 million hectares of agricultural land were managed organically by at least 3.1 million farmers. With the most organic agricultural land in Australia (35.69 m hectares) followed by Argentina (3.63 m hectares) and the Spain (2.35 m hectares). According to FiBL survey 2021 India holds a unique position among 187 countries practicing organic agriculture. India is home to 30% of total organic producers in the world having 2.30 million ha. The yield reduction in any crop due to weed competition depends on several factors such as weed flora and density, duration of competition, management practices and climatic conditions. Therefore, timely weed management is crucial for attaining optimal grain yield of a crop. However, none of the single weed control methods are effective for all weeds and to manage weeds effectively and sustainably in the long run, it is essential to develop and deploy flexible integrated weed management (IWM) practices for organic farm. IWM consists of physical, cultural, bio-herbicides, and biological means developed on knowledge of weed ecology and biology. Organic weed management is a holistic system involving an entirely different approach to managing a farming system. The organic farmer is not interested in eliminating all weeds but wants to keep the weeds at a threshold that is both economical and manageable. Methods/techniques involve in organic weed management *i.e* thermal weed control, soil solarization, mulching, stale seed bed, crop rotation, crop established and competition, allelopathy, in biological weed control little research has been conducted on using predatory or parasitic microorganisms or insects to manage weed populations. However, this may prove to be a useful management tool in the future and in chemical control a few herbicides are approved for organic production under the Final Rule. Some materials that are approved, such as corn gluten and acetic acid, tend to have low efficacy. It is recommended that farmers try the techniques listed above and use organic herbicides as a last resort. More research is needed to predict when a farmer should take action to control weeds to achieve optimum benefits. Having a thorough understanding of the biology of weeds and the interaction between weeds and crops will further help farmers make weed management decisions. Unfortunately, the vast number of weed and crop combinations makes knowing the optimum time and techniques to control weeds seem impossible. Instead, it has been recommended to use models that take into account the environment, the weed species, and the crops grown to predict optimum weeding times. However, much more additional research is needed to develop such comprehensive models.

Non-chemical weed management in *Rabi* fennel under organic farming conditions

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A field experiment was conducted during the *Rabi* seasons of the years 2019-20 and 2020-21 on loamy sand soils of Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Gujarat to study the effect of non-chemical weed management in *Rabi* fennel under organic farming conditions. Weed management in organic production systems involve the use of many techniques and strategies, all with the goal of achieving economically acceptable weed control and crop yields. The eight treatments, *viz.* T_1: stale seed bed *fb* 1 HW at 30 DAS, T_2: castor shell mulch 5 t/ha *fb* HW at 30 DAS, T_3: mustard straw mulch 5 t/ha *fb* HW at 30 DAS, T_4: sun hemp mulch 5 t/ha *fb* HW at 30 DAS, T_5: wheat straw mulch 5 t/ha *fb* HW at 30 DAS, T_6: inter-culturing *fb* HW at 30 DAS and 60 DAS + earthing up at 70 DAS, T_7: two IC at 30 and 60 DAS + earthing up at 70 DAS, T_8: weedy check were evaluated in randomized block design with three replications. The maximum weed control efficiency (66%) was observed under stale seed bed *fb* 1 HW at 30 DAS (T_1), whereas the minimum weed control efficiency was recorded under sunhemp mulch 5 t/ha *fb* HW at 30 DAS (T_4). However, the lowest weed index was recorded under stale seed bed *fb* 1 HW at 30 DAS (T_1) while the maximum weed index was observed under two IC at 30 and 60 DAS + earthing up at 70 DAS (T_7).The pooled results indicated that significantly highest seed yield (1.43 t/ha) of fennel was recorded with Inter-culturing *fb* HW at 30 DAS and 60 DAS + earthing up at 70 DAS (T_6) over rest of the treatments except treatment T_1 (Stale seed bed *fb* 1 HW at 30 DAS). Similarly, stalk yield of fennel was recorded significantly higher with Inter-culturing *fb* HW at 30 DAS and 60 DAS + earthing up at 70 DAS (T_6) and it was at par with all the treatments except treatments T_7 and T_8. Inter-culturing *fb* HW at 30 DAS and 60 DAS + Earthing up at 70 DAS (T6) recorded the maximum net returns (₹ 3294/ha), whereas maximum benefit: cost ratio (1.68) was observed under stale seed bed *fb* 1 HW at 30 DAS (T_1). The higher B:C ratio in stale seed bed *fb* 1 HW at 30 DAS was due to lower treatment cost compared to other treatments.

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Number dependent population dynamics and damage potential of bioagent *Cyrtobagous salvinae* on water fern *Salvinia molesta*

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Salvinia molesta, commonly known as "water fern" is an aggressive and a fast-growing invasive alien aquatic weed of the South-Eastern Brazil origin. This species is widespread in Australia, New Zealand, the Southern USA, the Indian subcontinent, South-East Asia, some Pacific islands and 20 countries of Africa continent. In view of its gravity, it was added in the list of the World's 100 most invasive weeds of the world. The weed affects irrigation, hydroelectric generation, water availability and navigation choking rivers, canals, lagoons besides drastic reduction in fish production. *S. molesta* was first seen in 1950s in Veli Lake of Thiruvananthapuram in Kerala in India which invaded soon all the water bodies throughout the state within next 10 years also many reservoirs in other states of South India besides its spread scattered occurrence in in Odisha. In central India, first time during a survey, severe infestation of *Salvinia molesta* was noticed in Satpura reservoir at Sarni in district Betul of Madhya Pradesh in more than 70% out of total 1100-hectare area of reservoir. Later its occurrence was noted in many water bodies in district Katni and Jabalpur (Madhya Pradesh), Durg and Balod (Chhattisgarh) and Gadhchiroli, Chandrapur, Bhandara, Yavatmal (Maharashtra). Biological control of this weed was considered a potential and effective method. Under any biological control programme, it is necessary to know the required number of bioagent to make the control effective in the given time. An experiment was conducted to know the appropriate number of releases of bioagents and the time required to control the weed in per hectare area. After release of different numbers of bioagent in the water tanks, substantial increase in adult population was observed after 135 days corresponding to initial number of releases. There was no significant increase in population up to 3 months. Initially there was no dry weight increase observed in the treatments, but after 135 days it started to show difference in different treatments as per the release load of bioagent. There was an increase in brownness corresponding with the increase in number of insects. Where insects were released at the rate of 22800/ha, 38.8% brownness was found in 135 days while under 159254/ha adult's release, brownness was observed to the tune of 81.3%. The trend of increase in insect population and damage on weed was positively correlated. There was no significant difference in time taken by release of about 45600/ha to 68400/ha and 91254/ha to 159000/ha. The time taken to control the weed completely by release of bioagent @ 22800/ha was 15 months while it was 12.5 months by the release of bioagents @ 45600/ha to 68400/ha. There was significant difference in time required to control the weed completely by release of bioagents in number of 22800, 45000 and 91254/ha, however, difference in time was only about 2.5 months between 22800 and 45600/ha and 1.0 month between 68400, 114000 and 159000/ha.

Bio efficacy of mycoherbicides against alien invasive weeds Parthenium, Lantana and Water hyacinth: Commercialization perspectives

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Invasive weeds pose a serious threat to the biodiversity of natural ecosystems and a significant constraint to agricultural production worldwide. Due to the recent trends in environmental awareness concerning the side effects of herbicides, public pressure is mounting to force industry to develop safer, more environmentally friendly approaches for controlling weeds. Fungus or their metabolites-based pesticides, referred to as mycoherbicide, for the management of weeds offer such an approach. The use of mycoherbicide has proven to be a potentially efficacious, cost-effective, and safe option for the management of weeds. Considerable progress has been made during the past four decades in the use of fungi as biocontrol agent of weeds. There has been a great number of naturally occurring fungal strains researched for possible use as mycoherbicides, but only a small proportion have been developed as commercial products. Currently, a total of 17 mycoherbicides (8 in the USA, 4 in Canada, 2 in South Africa, and 1 each in the Netherlands, Japan, and China) have been registered around the globe. The advancement of formulation techniques is of paramount importance to the continued development of mycoherbicides. It is also essential to continue intensive screening programs for the selection of fungal pathogens, especially hemibiotrophs, if mycoherbicides are to become a viable component of integrated weed management in the future. Recent trend is the application of several host-speciûc fungal pathogens in a bioherbicide mixture as a multicomponent bioherbicide system for simultaneous, broad-spectrum weed biocontrol. Pathogens of common weeds are also able to produce a wide array of toxins, bioactive metabolites with different biological activities, chemical structures, mechanism of action, and specificity with respect to plants, environmental impact and stability. Some of the advantages of mycoherbicide over traditional chemical herbicides are their specificity for the target weed; absence of adverse effects on humans, wildlife or domestic animals; rapid degradation and absence of residues in surface or ground water, crops, soil or food chains. We have made significant progress in the development and application of isolated and patented fungal pathogens for some invasive weeds of India. This paper will discuss the progress on those mycoherbicide for the management of invasive weeds viz., Parthenium, Lantana and Water hyacinth. The possibility and commercialization perspectives for obtaining new herbicides from these fungi are discussed in this paper.

Non-chemical weed management in bhendi (*Abelmoschus esculentus* L.)

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Bhendi is a major warm-season vegetable crop grown extensively in tropical and subtropical regions of the world for its young tender fruits. It contains high percentage of vitamins, proteins, minerals, and dietary fibre, as well as its low calorific value and zero trans-fat. Weeds are generally controlled through cultural, physical, mechanical, and chemical methods, with hand weeding being the most effective. Herbicides are the quickest and cheapest way to control weeds, but relying solely on herbicides for weed management is not ideal because it leads to herbicide persistence, resistance, and a shift in weed flora. Hence, there is a need to identify alternative organic methods of weed management approaches. Because of the slow growth rate and wider row spacing of the crop, heavy infestation by grasses and broad-leaved weeds at early stage of the crop cause around 70% yield loss in Bhendi. Intercropping suppresses weeds more effectively than sole cropping and thus allows the use of crops for weed management. Mulching, in addition to enhancing the economic output of crops by creating a favourable environment for their growth, also helps to manage weeds. Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore to identify the effective non-chemical weed management practices in Bhendi. The experiment was laid out in randomized block design (RBD) with three replications. The treatment consisted of nine non-chemical weed management practices, *viz.*, intercropping with sunhemp + insitu incorporation on 30 days after seeding (DAS), intercropping with dhaincha + insitu incorporation on 30 DAS, intercropping with cowpea + insitu incorporation on 30 DAS, rice straw mulch 5t/ha with one hand weeding on 20 DAS, corn cob and husk mulch 5t/ha with one hand weeding on 20 DAS, sugarcane trash mulch 5t/ha with one hand weeding on 20 DAS, groundnut shell mulch 5t/ha with one hand weeding on 20 DAS, hand weeding twice on 20 and 30 DAS and weedy check. Sugarcane trash mulch 5t/ha with one hand weeding on 20 DAS resulted in significantly higher bhendi plant height, dry matter production, leaf area index, crop growth rate and yield attributes like fruit length (12.40 cm), fruit girth (1.77 cm), individual fruit weight (11.53 g), number of fruits plant-1 (23.13), fruit yield plant-1 (0.267 kg plant-1) yield of organic bhendi (19.75 t/ha) and also recorded higher net returns (¹ 188831/ha) and B C ratio (2.74). Next best treatment was paddy straw mulching 5t/ha with one hand weeding on 20 DAS. This was due to the increased nutrient uptake by the crop and reduced nutrient removal by the weeds at all stages of the crop. It may be concluded that mulching and intercropping can be used as a sustainable non-chemical weed management practice for controlling weeds and improving the productivity of organic bhendi.

TECHNICAL SESSION 6

Weed management in pulses

Weed management in lentil with mulching and herbicide

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A field experiment was conducted during the *Rabi* season of 2021 at the Agricultural Farm of the Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal to study the response of lentil to weed management using mulching and pre-emergence herbicide and pre-emergence *fb* post-emergence herbicide treatments. The experimental field is situated at about $23^{0}66.872$ N latitude and $87^{0}65.962$ E longitude with an average altitude of 84 m above the mean sea level. The soil of the experimental field was sandy loam in texture, medium in phosphorus and low in nitrogen and potash with acidic reaction. The experiment consisting of two factors - mulching and herbicide having twelve treatment combinations. It was laid out in a factorial randomized block design with three replications. Three mulching treatments, *viz.* straw mulching at 4 t/ha, soil mulching and no mulching and four herbicides treatments, *viz.* pre-emergence application (PE) of pendimethalin at 1000 g/ha, post-emergence application (PoE) of imazethapyr at 50 g/ha, pendimethalin PE *fb* imazethapyr PoE and no herbicide, were evaluated in this experiment. The lentil cultivar 'WBL –77' (Moitree) was used. The lentil crop was infested with six weed species belonging to four botanical families. *Digitaria sanguinalis, Cynodon dactylon, Echinochloa colona* among the grasses; *Cyperus rotundus* among the sedges and *Spilanthes acmella* and *Chenopodium album* among the broad-leaved weeds were predominant throughout the cropping period. The treatment straw mulching recorded significantly lower values of weed density, biomass and higher values of weed control efficiency, growth attributes, seeds per pod and seed yield of lentil. Straw mulching alone at 4 t/ha registered lower density of total weeds controlling about 40% as compared to no mulching. Integrated use of pendimethalin 1000 g/ha PE *fb* imazethapyr 50 g/ha PoE registered the lower density as well as biomass of grassy, broad-leaved, sedge and total weeds at 60 days after seeding (DAS). Higher yield was obtained with straw mulching than soil mulching and no mulching. Similarly, pendimethalin 1000 g/ha PE *fb* imazethapyr PoE recorded highest lentil seed yield among herbicidal treatments. The loss of lentil seed yield due to weed competition was to the tune of 30-65% and it was comparatively less in straw mulching and herbicide combination. Pendimethalin 1000 g/ha PE *fb* imazethapyr 50 g/ha PoE + straw mulching at 4 t/ha were found to be effective in controlling composite weed flora and registered lower values of weed density, total weed biomass and higher values of growth and yield attributes of lentil. Thus, integrated use of pendimethalin 1000 g/ha PE *fb* imazethapyr PoE + straw mulching 4 t/ha proved to be a promising approach for effective weed management and obtaining higher productivity of lentil.

Herbicide-based weed management in urdbean and its carry over effect on succeeding *Rabi* crop

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A field experiment was carried out during the *Kharif* season of three consecutive years from 2017 to 2019 at Pulse Research Station, S. D. Agricultural University, Sardarkrushinagar, Gujarat to study the herbicide-based weed management in urdbean and its carry over effect on succeeding *Rabi* crop. Eleven treatments were tested including: T1 : weedy check, T2 : pre-emergence application (PE) of pendimethalin 1.0 kg/ha, T3 : pendimethalin 30 EC + imazathapyr 2 EC 0.75 kg/haPE,T4 : post-emergence application (PoE) of imazathapyr 40 g/ha T5 : imazamox 35 WG +Imazathapyr35 WG 40 g /ha PoE, T6 : imazamox 35 WG +Imazathapyr35 WG 60 g /ha PoE, T7: clodinafop propargyl 8% + acifluorfen-sodium 16.5% 125 g/ha PoE,T8: clodinafop-propargyl 8% + Aciflourfen-sodium 16.5% 187.5 g/ha at PoE,T9 : manual weeding twice at 15-20 and 35-40 days after seeding (DAS), T10: T2 + IC *f*b manual weeding at 25-30 DAS, T11:T3 + IC *f*b manual weeding at 25-30 DAS. A randomized complete block design with 3 replications was used. Post-emergence herbicides were applied at 15-20 DAS. Significantly higher seed yield (1.020t/ha) was recorded with manual weeding twice at 15-20 and 35-40 DAS (T9) while higher straw yield (4.044 t/ha) was recorded with T2 + IC *f*b manual weeding at 25-30 DAS (T10) as per pooled results. Significantly the lowest weeds biomass at 30 DAS was recorded with T11 while at 60 DAS, lowest weed biomass was recorded with T9. Highest weed control efficiency was recorded with manual weeding twice at 15-20 and 35-40 DAS (T9) in individual as well as pooled results. No phytotoxic effect of herbicides was observed on succeeding *Rabi* crops (wheat and rajmash). The economic analysis revealed highest net returns (₹ 33786/ha) with manual weeding at 15-20 and 35-40 DAS (T9) and with T2 + IC *f*b manual weeding at 25-30 DAS (T10) (₹ 32937/ha). While, highest B:C ratio of 1.38 was obtained with T10. It can be concluded that pendimethalin 1 kg/ha PE followed by intercuturing and hand weeding at 25-30 DAS or pendimethalin + imazethapyr (ready mixture) 0.75 kg/ha PE followed by intercuturing and hand weeding at 25-30 DAS or clodinafop-propargyl + aciflourfen-sodium 187.5 g/ha PoE are effective in economically managing weeds and obtaining higher seed yield in urdbean.

Bio-efficacy of new generation herbicides in chickpea

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Chemical weed control in chickpea is confined to pre- plant incorporation of fluchloralin 750 g /ha and pre-emergence application (PE) of pendimethalin 1000 g/ ha in most of the chickpea growing areasin India. Hence, there is an urgent need to identify broad-spectrum new generation herbicide molecules that offer effective weed control during the critical period of weed competition to improve the productivity as well as profitability of chickpea. Therefore, a study was conducted at Agricultural Research Institute, Main Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India during *Rabi* 2020 to evaluate the efficacy of herbicides in chickpea (*Cicer arietinum* L.) variety 'JG-11'. The experiment was conducted with 12 treatments and three replications (RCBD) viz;T_1: pendimethalin 1 kg/ha PE followed by (*fb*) mechanical weeding at 20 and 40 days after seeding (DAS), T_2: pendimethalin 30% + imazethapyr 2% EC (Ready Mix- RM) 1 kg/ha PE *fb* mechanical weeding at 30 DAS, T_3: oxyfluorfen 140 g/ha PE *fb* mechanical weeding at 20 and 40 DAS, T_4: post-emergence application (PoE) of imazethapyr 60 g/ha *fb* mechanical weeding at 40 DAS, T_5: topramezone 25.2 g/ha PoE *fb* mechanical weeding at 40 DAS, T_6: imazethapyr 35% + imazamox 35% WG (RM) 70 g/ha as (PoE *fb* mechanical weeding at 40 DAS, T_7: propaquizafop 10% EC + imazethapyr 10% SL (TM) (62.5 + 60) g/ha PoE *fb* mechanical weeding at 40 DAS, T_8: quizalofop ethyl 5% EC + imazethapyr 10% SL (TM) (50+ 60) g/ha PoE *fb* mechanical weeding at 40 DAS, T_9: acifluorfen 16.5% + clodinofop-propargyl 8% EC (RM) 245 g/ ha PoE *fb* mechanical weeding at 40 DAS, T_{10}: fluazifop-p-butyl 11.1 + fomesafen 11.1% SL (RM) 250 g/ ha PoE *fb* mechanical weeding at 40 DAS,T_{11}: mechanical weeding at 20 and 40 DAS, T_{12}: weedy check. Pendimethalin 30% EC + imazethapyr 2% EC (RM) 1.0 kg/ha PE *fb* mechanical weeding at 30 DAS recorded lowest weed density (51.00/ m^2 and 21.30/ m^2 at 20 and 40 DAS, respectively) and also recorded lowest weed biomass of 0.64g/$m^2$and 4.51g/m^2 at 20 and 40 DAS, respectively. T_2 treatment also recorded highest weed control efficiency (88.09%) and herbicide control efficiency (3.89%) at 40 DAS. All the post emergent herbicide treated plots, *viz.*, (T_4,T_5,T_6,T_7,T_8,T_9 and T_{10}) showed phytotoxicity in chickpea followed by T_5 andT_6 treatments showed some residual effects in bioassay experiment.T_1, T_3andT_2 registered 1.95, 1.94 and 2.08 t/ha seed yield, respectively as against seed yield of 1.11 t/ha in weedy check. Maximum net returns (₹ 72093 /ha) was recorded with pendimethalin + imazethapyr (RM) 1.0 kg/ha PE *fb* mechanical weeding at 30 DAS (T_2) with B:C ratio of 3.27, which was closely followed by oxyfluorfen 140 g/ha PE *fb* mechanical weeding at 20 and 40 DAS (T_3) with net returns of ₹ 64980/ha and B:C ratio of 2.99.

Bioefficacy of new generation herbicides in *Rabi* greengram

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Herbicide use is increasingly being adopted around the world due to non-availability and high wages of labour. Greengram is a short duration crop with slow initial growth and faces severe weed infestation. Thus, identifying the new molecules of herbicides is needed. A field experiment was conducted during *Rabi* season 2020-21 at Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad to study the bioefficacy of new generation herbicides in managing weeds and imporoving productivity of *Rabi* greengram. Treatments included were: pre-emergence application (PE) of diclosulam 84% WDG 26 g/ha (W_1), pendimethalin 30% EC + imazethapyr 2% EC 960 g/ha PE (W_2), post-emergence application (PoE) of Imazethapyr 35% + Imazamox 35% WG 70 g/ha (W_3), imazethapyr 3.75% + propaquizafop 2.5% w/w ME 125 g/ha PoE (W_4), sodium-acifluorphen 16.5% EC + clodinafop-propargyl 8% EC 250 g/ha PoE (W_5), diclosulam 84% WDG 26 g/ ha PE followed by (*fb*) imazethapyr 10% SL 75 g/ha PoE (W_6), imazethapyr 10% SL + quizalofop ethyl5% EC (tank mix) 125 g/ha PoE (W_7), intercultivation at 20 DAS with power weeder (W_8), unweeded check (W_9)and weed free check (W_{10}). Higher weed control efficiency (WCE) was noted with diclosulam 84% WDG 26 g/ ha PE *fb* imazethapyr 10% SL 75 g/ha PoE (W_6) (92.15%) and diclosulam 84% WDG 26 g/ha PE (90.59%). On the contrary, higher weed indices are observed with the above diclosulam treated plots (W_6-88.25 and W_1-88.57%) due to phytotoxic effect of herbicide on the crop which resulted in lower plant height (W_6-24.80 and W_1-23.00 cm), lower plant dry matter production (W_6-817 and W_1-781 kg/ha) and lower seed yield (W_6-168 kg/ha and W_1-164 kg/ha). Apart from the diclosulam treated plots, imazethapyr 10% SL + Quizalofop ethyl 5% EC (tank mix) 125 g/ha PoE at 20 DAS (W_7) has recorded higher weed control efficiency, greengram plant height (46.87 cm), dry matter production (3963 kg/ha), nutrient uptake (72.39, 12.58 and 75.01 kg NPK/ ha) and seed yield (1375 kg/ha) which was found on par with weed free check.

Effect of pre- and post-emergence herbicides on weeds and yield of summer greengram

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Pulses are rich source of protein and amino acids. Pulses maintain soil fertility through nitrogen fixation process in symbiotic association with *Rhizobium* bacteria present in their root nodules. In Gujarat, area under greengram was 86.84 lakh ha with the production of 49.15 tonnes and productivity of 566 kg/ ha. In *Kharif* season, it is mainly grown in the districts of Kheda, Panchmahal, Vadodara, Mehsana, Banaskantha and Kutch. However, it is grown in very large area in summer season in Kheda, Vadodara and Panchmahal districts where assured irrigation facilities are available. However, in cultivation of greengram, weed infestation is one of the major constraints. Infestations of weeds, especially at early stages of crop growth, possess considerable threat in achieving desired yield of greengram. Competition with the weeds leads to 30 to 80% reduction in seed yield of greengram during summer and *Kharif* seasons and 70 to 80% during *Rabi* season. The present experiment was undertaken to evaluate the effect of pre- and post-emergence herbicides on weeds and yield of summer greengram (*Vigna radiata* L.). The field experiment was conducted in loamy sand soil during summer season of 2020 at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. There were ten treatments tested under randomized block design with three replications. The dominant weed species observed in the experiment were:, *Digitaria sanguinalis* (L.) Scop, *Eleusine indica* L. and *Dactyloctenium aegyptium* L. (Willd) among monocot and the dicot weeds: *Digera arvensis* (L.) Mart., *Portulaca oleracea* L., *Trianthema monogyna* L. and *Phyllanthus niruri* L.. The pre-emergence application (PE) of either pendimethalin 750 g/ha or pendimethalin + imazethapyr (pre-mix) 750 g/ha or oxyfluorfen 117.5 g/ ha PE or inter-cultivation twice and hand weeding twice at 20 and 40 days after seeding (DAS) significantly reduced the density and biomass of monocot and dicot weeds, recorded higher weed control efficiency; higher greengram growth; yield attributes, *viz.*, plant height plant dry biomass, nodule dry weight, number of pods/plant; seed yield; net return and benefit cost ratio (B:C). Further, none of the applied herbicide showed phototoxic effect on summer greengram.

Poster 113

Bioefficacy of toperamezone on weeds, growth and productivity of chickpea

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Weeds compete with crop plants for moisture, nutrients and sunlight and thereby reduce yields. An experiment was planned to study the bioefficacy of toperamezone at different doses and time of application on weeds, and growth and productivity of chickpea. The field experiment was conducted during *Rabi* (winter) 2020-21 and 2021-22 at the research farm of Punjab Agricultural University, Ludhiana (30° 54´N, 75° 48´E, altitude 247 m), India. The soil of the experimental site was loamy sand, having pH 7.5, organic carbon 0.26% (low), available N 126.0 kg/ha (low), available P 19.1 kg/ha (medium), and available K 158.5 kg/ha (medium). A total rainfall of 55.7 and 157.7 mm (January) was received during the crop growing seasons of 2020-21 and 2021-22, respectively. The mean monthly maximum temperature (25.3 and 26.8 °C) and minimum temperature (9.8 and 10.7 °C) during November 2020 and 2021, respectively, and the mean monthly maximum temperature (19.6 and 20.7 °C) and the mean monthly minimum temperature (7.2 and 6.8 °C) during December 2020 and 2021, respectively reflected small drop down. Ten treatments, *viz.* toperamezone 20.6 g/ha at 14, 21 & 28 days after sowing (DAS), toperamezone 25.7 g/ha at 14, 21 and 28 DAS, quizalofop ethyl 100 g/ha at 21 DAS, hand weeding (HW) at 30& 60 DAS, weedy and weed free checks, were arranged in a randomized complete block design with four replications. The crop was sown on 3rd November and 16th November in 2020 and 2021, respectively. The sowing of variety PBG 8 was done in rows 30 cm apart using a seed rate of 45 kg/ha. These herbicides were sprayed with knapsack backpack sprayer fitted with three flat fan nozzlw boom using 375litres of water per hectare. The major weed flora of the field constituted of *Oenothera laciniata*, *Coronopus didymus*, *Medicago denticulata*, *Rumex dentatus*, *Chenopodium album* and *Anagallis arvensis*. Density and dry weight of weeds were significantly lower in all the treatments than weedy check. Treatment of weed free recorded the highest grain yield of chickpea, which was, however, statistically at par with two hand weedings, toperamezone 20.6 g/ha at 14 DAS and toperamezone 25.7 g/ha at 14 DAS in 2020-21 and at par with two hand weedings and significantly better than the other treatments in 2021-22.However, in 2021-22, the lowest grain yield was recorded in the treatment of toperamezone 25.7 g/ha followed by 20.6 g/ha at 14 DAS due to severe phytotoxicity on the crop.Toperamezone 20.6 g/ha at 14 DAS in 2020-21 and 25.7 g/ha at 21 DAS in 2021-22 was found effective in controlling weeds and thereby increasing the grain yield of chickpea. Furthermore, high temperatures caused severe phytotoxicity on the crop and resulted in a severe yield reduction during the second year. Therefore, it can be concluded that post-emergence application of toperamezone (20.6 or 25.7 g/ha at 14 DAS) at a high temperature was not found safe for the crop. However, post-emergence application of toperamezone (20.6 or 25.7 g/ha at 14-21 DAS) provided higher yield by effective control of weeds at normal temperature. These further warrants to be very cautious while opting for such an herbicide or not in chickpea as minor tempertature variations may invite unexpected yield losses.

Response of gram to different pre- and post-emergence herbicides under South Gujarat conditions

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A field experiment was conducted during *Rabi* season of 2016-17 at N. M. College of Agriculture, NAU, Navsari to study the "Response of gram to different pre- and post-emergence herbicides under south Gujarat conditions". Ten treatments of weed management practices, *viz.*T_1: pendimethalin 0.75 kg/ha as pre-emergence, T_2:Pendimethalin 0.75 kg/ha as pre-emergence *fb* 1 H.W at 20 DAS, T_3: pendimethalin 0.75 kg/ha as pre-emergence *fb* imazethapyr 16.5 g/ha at 20 DAS as post-emergence, T_4:pendimethalin 0.75 kg/ha as pre-emergence*fb* (imazethapyr 35% + imazamox 35% 20 g/ha) at 20 DAS as post-emergence, T_5: pendimethalin 0.75 kg/ha as pre-emergence *fb* propaquizafop 0.75 kg/ha at 20 DAS as post-emergence, T_6: pendimethalin 0.75 kg/ha as pre-emergence *fb* (propaquizafop2.5% + imazethapyr 3.75%) 0.57 kg/ha at 20 DAS as post-emergence, T_7: Pendimethalin 0.75 kg/ha as pre-emergence *fb* quizalofop-p-ethyl 40 g/ha at 20 DAS as post- emergence, T_8: pendimethalin 0.75 kg/ha as pre-emergence *fb* fenoxaprop-p-ethyl 37.2 g/ha at 20 DAS as post-emergence, T_9: weed free,T_{10}: uncontrol (weedy check) were evaluated in a randomized block design with three replications. Treatment T_8 being at par to T_3 and T_7 resulted in significantly lower number of monocot weeds, whereas treatment T_5 being at par to T_4 and T_3 recorded lower number of dicot weeds at 20 DAS than rest of the treatments. Treatment T_2 recorded the lowest number of monocot and dicot weeds at 40 DAS than rest of the treatments. Similarly, number of monocot weeds at 60 DAS were noted significantly lower under treatment T_6 being at par with treatment T_7, T_5 and T_4. Number of dicot at 60 DAS were recorded significantly lower under treatment T_3, T_5 and T_4 than other treatments. At harvest, treatment T_6, T_4 and T_5 were found equal for lower number of monocot and dicot weeds over other treatments. Treatment T_6 and T_4 resulted in lower dry weight of weed at 60 DAS and harvest but it remained at par with treatment T_5 and T_3 at 60 DAS. Treatment of weed free condition up to harvest showed its superiority for number of pods/plant and seed yield/plant over other treatments but it remained statistically at par with pendimethalin 0.75 kg/ha as pre-emergence *fb* fenoxaprop-p-ethyl 37.2 g/ha at 20 DAS as post–emergence, T_7 (pendimethalin 0.75 kg/ha as pre-emergence *fb* quizalofop-p-ethyl 40 g/ha at 20 DAS as post-emergence) and T_2 (pendimethalin 0.75 kg/ha as pre-emergence*fb* 1 H.W at 20 DAS). And similar trend was also observed for seed yield and stover yield of chickpea. Treatment T_9, T_8, T_7 and T_2 noted 54.9, 51.2, 50.3 and 49.7 per cent increases in seed yield of chickpea over weedy check. Treatment T_8 resulted in maximum net return of ₹ 70622/ha and higher B:C ratio of 2.88 which was followed by treatment T_2, T_7 and T_9.

Optimum dose and time of application of topramezone for weed management in chickpea

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Chickpea is the major pulse crop of India. The productivity of chickpea is affected by various biotic and abiotic factors. Poor weed management is one of them cause of reduction in chickpea yield. Application of broad spectrum post-emergence herbicide is a promising weed management option for chickpea. So, current experiment was aimed to find out optimum dose and time of application of topramezone herbicide for weed management in chickpea (*Cicer arietinum* L.) at *Agronomical Research Farm, RPCAU, Pusa, Bihar,* during the *Rabi* season of 2020-21. The existing crop variety of chickpea was '*GNG-2299*'. The field consisted of 10 treatments, *viz.* topramezone 20.6g/ha at 14, 21 and 28 DAS (T_1, T_2 and T_3), topramezone 25.7g/ha at 14, 21 and 28 DAS (T_4, T_5 and T_6), quizalofop-p-ethyl 100 g/ha at 25 DAS (T_7) applied as post-emergence (PoE), imazethapyr complex (pendimethalin 30% + imazethapyr 2%) 1000 g/ha applied as pre-emergence (PE) *fb* one hand weeding at 30 DAS (T_8), weed free check (two hand weeding at 30 and 50 DAS) (T_9) and weedy check (T_{10}). Among all herbicidal treatments, pre-emergence (PE) application of imazethapyr complex (pendimethalin 30% + imazethapyr 2%) 1000g/ha + hand weeding at 30 DAS treatment recorded maximum reduction in total weed density (89.7%), total weed dry weight (83%) and recorded highest WCE (89.6%) as compared to weedy check treatment. Among post-emergence applied herbicides, topramezone application at 14 days caused high phytotoxicity (3-4) on crop and application at 28 days after sowing less effective on weeds but application of topramezone at 21 DAS controlled all broad and narrow leaved weeds (rating 8-10) without crop injury. Among all doses and time of applications of topramezone sprayed plots, topramezone 25.7 g/ha (PoE) at 21 DAS recorded significantly lower NLWs density (16-44%), BLWs density (24-67%) and total weed dry weight (23-59%) than other doses and time of applications of topramezone. However, spray of topramezone 25.7 g/ha (PoE) after 14 and 21 days of sowing, both controlled weed properly (rating 8-10) but after 14 days of sowings applied dose caused more phytotoxicity to crop, as well as weeds also emerge due to slow early crop growth.Among herbicidal treatments, pre-emergence application of imazethapyr complex 1000 g/ha *fb* hand weeding at 30 DAS treatment (T_8) recorded highest seed yield (1.50 t/ha), WCE (89.6%), net return (40670 ₹/ha) and B:C ratio (2.17), *fb* topramezone 25.7 g/ha (PoE) applied at 21 DAS treatment (T_5). Among PoE herbicide applications, highest seed yield was obtained from topramezone 25.7 g/ha applied after 21 days of sowing treatment, it produced 182% higher seed yield over weedy check treatment and it also produced 107-165% higher seed yield(1.31 t/ha) as compared to other doses and time of application of PoE applied herbicides. It can be inferred from the present investigation that among PoE applied herbicides, topramezone 25.7 g/ha at 21 DAS could be the best option for controlling narrow and broad leaves weeds in chickpea.

Effect of weed management practices and nitrogen levels on productivity of chickpea

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Chickpea (*Cicer arietinum* L.) is one of the most important *abi* pulse crops of India and occupies first position among the pulses. It was grown in an area of 8.4 million ha and producing 10.13 million tonnes with productivity of 1.07 t/ha during 2019-20 in India. Poor weed management is one of the most important yield limiting factors in chickpea. Being slow in its early growth and short statured plant, chickpea is highly susceptible to weed competition and weeds causes up to 75% yield loss. Excessive weed competition may adversely affect seed size which is an important quality parameter in chickpea. Initial 60 days is the period considered as too critical for weed crop competition in chickpea. Manual weed control is labour intensive and therefore, limits the production area. Nitrogen and weed control are the key to get maximum crop yield in most of the crops. In order to study the response of nitrogen levels and weed control practices on growth, productivity and economics of chickpea, a field experiment was conducted during *Rabi* season of 2019-20. The experiment consisting of twelve treatment combinations comprising two levels of nitrogen *i.e.*, 15 and 30 kg/ha and six treatments of weed control practices, *viz.*, W_1: Weed free, W_2: Unweeded, W_3: Pendimethalin 0.75 kg/ha as PE, W_4: Imazethapyr 75 g/ha as PoE at 25 DAS, W_5: Pendimethalin 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS and W_6: Imazethapyr 75 g/ha as PoE at 25 DAS + HW at 45 days after sowing. The results obtained during the course of investigation indicated that significantly higher plant height at harvest, number of branches at harvest, number of pods/plant, grain yield and B:C ratio of chickpea were recorded with 30 kg nitrogen per hectare. Among the different weed control practices significantly tallest plant at harvest, number of pods per plant and grain yield were recorded with weed free condition (W_1) but it was at par with pendimethalin 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W_5). Significantly the lowest plant height at harvest, number of pods per plant and grain yield were recorded by the application of imazethapyr 75 g/ha as PoE at 25 DAS (W_4) due to phytotoxic effect of imazethapyr but number of pods per plant and grain yield were at par with unweeded treatment (W_2). Whereas, the highest B:C ratio was obtained by treatment pendimethalin 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W_5) which was closely followed by weed free treatment (W_1).

Effect of tillage and weed management practices on weed dynamics and yield of lentil

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Lentil (*Lens culinaris* M.) is the second important *Rabi* pulse and fifth important pulse crop grown in India. Among various constraints in lentil production, weed is the most severe factor due to its short stature, long duration, and slow initial growth. Weeds are responsible for 60-84% of lentil yield losses. Being a poor competitor to weeds in the early stage, pre-emergence herbicides are recommended, whereas later emerging weeds compete with the crop. Thus, alternative herbicides, in addition to other weed management strategies, must be tested for successful weed control in lentil. The experiment entitled "Effect of tillage and weed management practices on weed dynamics and yield of lentil" was carried out during the *Rabi* season of 2020-21 at the *Research Farm* of *Tirhut College of Agriculture*, *Dholi* (25° 98' N latitude and 85°.60' E longitude) of *Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar*. The experiment was designed as a split-plot having 3 replications, with three tillage practices (zero tillage, minimum tillage and conventional tillage) and five weed management practices {weedy check, 1 hand weeding, chlorimuron-ethyl 4 g/ha (pre-emergence) + paddy straw mulching (5.0 t/ha), quizalofop-ethyl 40 g/ha (post-emergence) and chlorimuron-ethyl 4 g/ha (pre-emergence) *fb* quizalofop-ethyl 40 g/ha (post-emergence)}. The experimental field soil-texture was sandy-loam, having low organic carbon, available N and K while medium level of available P. The lentil variety *'HUL- 57'* was sown in first week of October with 30 cm × 10 cm spacing. The field was mainly infested with *Cynodon dactylon*, *Cyperus rotundus*, *Cannabis sativa*, *Sorghum halepense*, *Parthenium hysterophorus*, *Chenopodium album*, *Solanum nigrum,* and *Euphorbia hirta.* Tillage and weed management strategies increased lentil growth and yield. Among tillage practices, conventional tillage recorded significantly higher plant height, plant dry matter, pods/plant, grain yield (1.55 t/ha) and straw yield (1.93 t/ha) than zero tillage but was statistical at par with minimum tillage. Among weed management practices, hand weeding recorded significantly higher plant height, dry matter, pods/plant, grain yield (1.69 t/ha) and straw yield (2.01 t/ha) than quizalofop-ethyl 40 g/ha (PoE) and weedy check, but was found statistically at par with chlorimuron-ethyl (PE) + paddy straw mulching (5.0 t/ha) and chlorimuron-ethyl (PE) *fb* quizalofop-ethyl 40 g/ha (PoE). Among tillage practices, conventional tillage significantly reduced weed density and weed dry matter over minimum and zero tillage and recorded maximum weed control efficiency (72.26%). Likewise, weed management practices significant influence on weed dynamics over unweeded control. Among weed management practices, one hand weeding registered lower weed density and dry matter, contributing to highest weed control efficiency (90.97%) followed by chlorimuron-ethyl (PE) + paddy straw mulching (5.0 t/ha), chlorimuron-ethyl (PE) *fb* quizalofop-ethyl 40 g/ha (PoE). Whereas the highest B:C ratio was registered under chlorimuron-ethyl (PE) *fb* quizalofop-ethyl 40 g/ha (PoE) (1.84). Conventional tillage with 1 hand weeding effectively controlled weeds problem and registered maximum growth and yield, but considering the economical aspect, chlorimuron-ethyl (PE) *fb* quizalofop-ethyl 40 g/ha (PoE) is remunerative weed management option for lentil.

Integrated weed management in *Kharif* blackgram

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Blackgram [*Vigna mungo* (L.) Heppler] is one of the most important pulse crops grown throughout the India during *Kharif* season. It contributes about 13% of total pulse area and 10%of their total production in our country. In Gujarat, blackgram is cultivated in an area of 1.36 lakh hectare with the production of 0.87 lakh tons and average productivity is 0.636 t/ha. The lower productivity of blackgram was mainly due to higher weed infestation during early stages of crop growth which leads to reduction in yield up to 43.2-64.1%. In blackgram, weeds could be controlled by hand weeding. However, it is laborious, time consuming, costly and tedious. Moreover, many times labour is not available at the critical period of crop weed competition. Furthermore, during rainy season weather conditions do not permit timely hand weeding due to wet field conditions. Hence, use of herbicides offers an alternative for possible effective control of weeds. Thus, this study was conducted to study the integrated weed management in *Kharif* blackgram at Agricultural Research Station, Anand Agricultural University, Derol, Gujarat, in loamy sand soil during three consecutive *Kharif* season of 2016-17, 2017-18 and 2018-19. Eight treatments were studied in randomized block design with three replications. Among different weed management practices tested, post-emergence application (PoE) of propaquizafop 75 g/ha at 20 to 25 days after seeding (DAS) followed by (*fb*) intercultivation (IC) *fb* hand weeding (HW) at 30 DAS or quizalofop-ethyl 50 g/ha PoE *fb* IC + HW at 30 DAS or fenoxaprop-p-ethyl 67.5 g/ha PoE *fb* IC + HW at 30 DAS were found most efficient in reducing weed density and biomass with higher weed control efficiency. Yield reduction due to weeds competition was minimum (4.7%) with IC *fb* HW carried out at 20 and 40 DAS. Propaquizafop 75 g/ha PoE *fb* IC + HW at 30 DAS or quizalofop-ethyl 50 g/ha PoE *fb* IC + HW at 30 DAS or fenoxaprop-p-ethyl 9 67.5 g/ha PoE *fb* IC + HW at 30 DAS also recorded significantly higher seed yield and haulm yield of *Kharif* blackgram with higher net returns and benefit cost ratio as compared to other treatments. None of the applied herbicides in *Kharif* blackgram showed phytotoxic effect on succeeding maize, gram and wheat.

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Efficacy of pre- and post-emergence herbicides on weed control in blackgram under vertisol

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Blackgram (*Vigna mungo* L.) is an important legume crop grown in tropical and sub-tropical regions of the world and it have high protein in its seeds. India is the largest producer and consumer of *Kharif* blackgram in the world. Severe crop losses have been observed due to weeds in blackgram crop because of short statured growth habit and slow initial growth. The loss of grain yield in blackgram due to weeds range from 50-87% and critical period for crop weed competition is around 15 to 45 days after seeding (DAS). Hand weeding and inter-culturing are effective, but not feasible due to poor soil physical condition and unavailability of labour. In this context, use of herbicides can play vital role in management of weeds. Hence, integrated weed management has gained importance. A field study was conducted at Research Station, Department of Agronomy, Agriculture University, Kota during the year 2020 on vertisol soil. The soil of experimental field characterized as clay loam in texture, having neutral pH, moderate organic carbon status, good electrical conductivity, low nitrogen content, medium available potassium content and high available phosphorus. In the experimental field, predominant weed flora was *Parthenium hysterophorus, Digera arvensis, Celosia argentea, Cyperus rotundus, Echinochloa crus galli, Eleusine indica, Cynodon dactylon and Commelina benghalensis*. Maintenance of weed free condition (hand weeding twice at 40 and 60 DAS) resulted in significant reduction in density of monocot, dicot and total weeds at 60 DAS. Among the weed management treatments, pendimethalin 1 kg/ha followed by (*fb*) propaquizafop 33.3 g/ha + imazethapyr 50 g/ha at 20 DAS recorded significantly lower weed biomass at 60 DAS, weed index and increased weed control efficiency as compared to weedy check. Similarly, significantly increased the number of nodules/plant (27.33), weight of nodules/plant (48.33 mg/plant), pods/plant (13.67), grain/pods (6.33), seed yield (827 kg/ha) and straw yield (1.39 t/ha) were also recorded with pendimethalin 1 kg/ha *fb* propaquizafop 33.3 g/ha + imazethapyr 50 g/ha at 20 DAS as compared to weedy check but was at par with pendimethalin 1 kg/ha *fb* fomesafen 220 g/ha + fluazifop-p-butyl 220 g/ha at 20 DAS and pendimethalin 1 kg/ha *fb* acifluorfen-sodium 140 g/ha + clodinafop-propargyl 70 g/ha at 20 DAS. Pendimethalin 1 kg/ha *fb* propaquizafop 33.3 g/ha + imazethapyr 50 g/ha at 20 DAS recorded higher net returns (21171 /ha), benefit: cost (0.81) and is closely followed by pendimethalin 1 kg/ha *fb* fomesafen 220 g/ha + fluazifop-p-butyl 220 g/ha at 20 DAS. No residual/carry over phytotoxicity of any herbicides was observed on blackgram crop under bioassay study. Pendimethalin 1 kg/ha *fb* propaquizafop 33.3 g/ha + imazethapyr 50 g/ha at 20 DAS has been proved economically feasible and viable weed management practice for rainfed *Kharif* blackgram considering the present condition of scarcity and high cost of labour under north-west region of India.

Chemical weed management in pigeonpea

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Pigeonpea [*Cajanus cajan* (L.)] being a *Kharif* season crop is highly infested with narrow and broad-leaved weeds. Due to wider row spacing and initial slow growth of pigeonpea, weeds pose a major problem to its productivity which may lead to its yield reduction up to 80%. Manual and mechanical methods of weed control are quite effective, but they are costly and time consuming and due to frequent rains, it becomes difficult to do hand weeding at proper time. Under given circumstances farmers needs alternate production system using chemical weed management that are more efficient, less labour intensive and offer a quick response enabling farmers to produce more at less costs. A field experiment was conducted during *Kharif* season of 2018-19 to find out the cost-effective weed management practices in pigeonpea. Soil of experimental field was sandy loam in texture having pH 7.58, organic carbon 0.40%, and 182, 16.4, 186.3 kg/ha available N, P and K, respectively. The treatments comprised of twelve weed management options, *viz.*, T1: imazethapyr 20 g/ha at 15 days after seeding (DAS), T2: imazethapyr 40 g/ha at 15 DAS, T3: imazethapyr 60 g/ha at 15 DAS, T4: imazethapyr 20g/ha at 30 DAS, T5: imazethapyr 40g/ha at 30 DAS, T6: imazethapyr 60g/ha at 30 DAS, T7: pendimethalin 750 g/ha as pre-emrgence application (PE), T8 pendimethalin 750 g/ha PE + quizalofop-ethyl 50 g/ha as post-emrgence application (PoE), T9: pigeonpea + blackgram intercropping, T10: metribuzin 250 g/ha PE, T11:weedy check and T12: weed free. The experiment was laid out in RBD with three replications. The application of imazethapyr 60 g/ha at 15 DAS recorded significantly lower weed density at all the growth stages of the crop as compared to other treatments. At 60 and 90 DAS, imazethapyr 60 g/ha 15 DAS recorded the lowest weed dry biomass (5.04 g/m^2) and (4.89 g/m^2), respectively. Weedy check recorded significantly higher weed index (40.53%), than all other treatments under study. While, at 60 DAS; higher weed control efficiency (80.38%) was noticed with imazethapyr 60 g/ha 15 DAS which was found statistically at par with imazethapyr 40 g/ha 15 DAS (80.16%), imazethapyr 40 g/ha 30 DAS (78.80%), imazethapyr 60 g/ha 30 DAS (78.88%) and significantly higher than rest of the treatments. The growth and yield attributing characters, *viz.* plant height, dry matter accumulation/plant, number of primary and secondary branches/plant, pods/plant, seeds/pod and seed yield/plant was higher with imazethapyr 40 g/ha at 15 DAS which was statistically at par with imazethapyr 60 g/ha at 15 DAS.

Weed management in blackgram

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An experiment was conducted at College farm, College of Agriculture, NAU, Campus Bharuch, on the weed management in blackgram (*Vigna mungo* (L.) Hepper) during *Kharif* season. The experiment was conducted in randomized block design with three replications that comprised of twelve weed management treatments, *viz*., weedy check, hand weeding twice at 15 and 30 days after seeding (DAS) (weed free), pre-emergence application (PE) of pendimethalin 1000 g/ha, post-emergence application (PoE) of imazethapyr 70 g/ha at 20 DAS, propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 20 DAS, pendimethalin 1000 g/ha PE followed by (*fb*) imazethapyr 70 g/ha PoE 30 DAS, pendimethalin 1000 g/ha PE *fb* propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 30 DAS, pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS, imazethapyr 70 g/ha PoE 20 DAS *fb* hand weeding 40 DAS, propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 20 DAS *fb* hand weeding 40 DAS, stale seed bed (using glyphosate), stale seed bed (using tillage). Significantly minimum weed density at 20 DAS and 40 DAS were observed with hand weeding twice at 15 and 30 DAS (weed free), which was at par with pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS. Further, lower weed biomass at 40 DAS was registered with pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS followed by hand weeding twice at 15 and 30 DAS. While, at harvest significantly lower weed biomass observed with pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS being at par with pendimethalin 1000 g/ha PE *fb* propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 30 DAS, propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 20 DAS *fb* hand weeding 40 DAS, pendimethalin 1000 g/ha PE *fb* imazethapyr 70 g/ha PoE 30 DAS and hand weeding twice at 15 and 30 DAS. Furthermore, weed control efficiency was maximum with pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS, followed by pendimethalin 1000 g/ha PE *fb* propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 30 DAS., Pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS also emerged as best treatment with reference to weed index. Pendimethalin 1000 g/ha PE *fb* hand weeding 30 DAS recorded significantly higher seed (1612 kg/ha) and stover (2418 kg/ha) yields of blackgram, and it was at par with pendimethalin 1000 g/ha PE *fb* propaquizafop 2.5% + imazethapyr 3.75% 2000 g/ha PoE 30 DAS, pendimethalin 1000 g/ha PE *fb* imazethapyr 70 g/ha PoE 30 DAS, hand weeding twice at 15 and 30 DAS (weed free).

Efficacy of combined herbicides in summer blackgram

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A field experiment was conducted during summer season of 2019 at the Hill Millet Research Station, Rajendrapur farm, N. A. U., Waghai to study “Efficacy of combined herbicides in summer blackgram (*Vigna mungo* L.)”. Ten weed management treatments, *viz.*, T_1: pendimethalin 900 g/ha as pre-emergence application (PE) followed by (*fb*) 1 hand weeding (HW) at 30 days after seeding (DAS), T_2: sodium acifluorfen + clodinafop-propargyl (RM) 250 g/ha as post-emergence application (PoE) at 20 DAS, T_3: imazethapyr + pendimethalin (RM) 750 g/ha PE, T_4: imazethapyr + imazamox (RM) 70 g/ha PE, T_5: imazethapyr + propaquizafop (RM) 125 g/ha PoE at 20 DAS, T_6: quizalofop-p-ethyl 100 g/ha PoE at 20 DAS, T_7: fenoxaprop-p-ethyl 100 g/ ha PoE at 20 DAS, T_8: HW twice at 20 and 40 DAS, T_9: unweeded control, T_{10}: weed free were evaluated on blackgram cv. GU-1. Plant height was increased notably from 30 days onwards where taller plants were observed under weed free (T_{10}) followed by treatments T_1, T_2, T_6 and T_8, whereas, the lowest plant height was observed under unweeded control (T_9). Treatment T_{10} recorded significantly higher number of branches per plant at harvest which was statistically at par with treatment T_2 (sodium acifluorfen + clodinafop-propargyl (RM) 250 g/ ha PoE at 20 DAS). The yield attributing characters, *viz.*, number of pods per plant and pod length were significantly influenced by various weed management treatments, whereas number of seeds per pod, test weight and harvest index were not significant influenced. The highest seed (1.08 t/ha), haulm (2.45 t/ha) yield, the highest protein content (24.17%) and protein yield (261.92 kg/ha) were recorded with weed free t (T_{10}) closely followed by treatments T_1, T_2 and T_8. Significantly lowest weed density (*viz.*, monocot, dicot and sedge) and weeds biomass at harvest (326.67 kg/ha), maximum weed control efficiency (83.20%) and lower weed index (7.98%) were recorded with HW twice at 20 and 40 DAS (T_8). The The treatment T_9 recorded the highest weed density and biomass at harvest and weed index. The highest gross return of ₹ 82,410/ha was obtained from weed free (T_{10}), while maximum net return (₹ 54,812/ha) and cost benefit ratio (1:2.86) were recorded with sodium acifluorfen + clodinafop-propargyl (RM) 250 g/ha PoE at 20 DAS (T_2).

Evaluation of post-emergence herbicides in greengram

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An experiment was conducted during *Kharif* 2021 at AICRP on MULLaRP, University of Agricultural, Sciences, Dharwad (Karnataka) under rainfed condition in medium black soil having soil pH- 7.3; soil organic carbon- 5.39/kg; available N- 219 kg/ha; available P- 29 kg/ha; available K- 482 kg/ha. Total rainfall received was 1052.3m, and 323.5 mm was received during the cropping period. The number of treatments in the experiment were ten including: T_1- unweeded control; T_2- weed free; T_3- hand weeding twice at 20 and 40 days after seeding (DAS); T_4- imazethapyr 55 g/ha; T_5- fluzifop- p-butyl 250 g/ha; T_6- propaquizafop 33.3 g + imazethapyr 50 g/ha (ready mix); T_7-aciflourfen sodium 140 g + clodinafop-propargyl 70 g/ha (ready mix); T_8- fomesafen + fluzifop-p-butyl 220 g/ha (ready mix); T_9- quizalfop-ethyl 50g/ha; T_{10}- propiquizafop 50g/ha and laid out in randomized block design with three replications. All the herbicides were sprayed as post-emergence (PoE) at 20 DAS. Major monocot weeds were: *Cynodon dactylon, Digitaria marginata, Dinebraretroflexa, Dinebra Arabica, Eluecine indica and Echinoclo sp*., broad leaved weeds were *Knoxium mollis, parthenium hysterophorus, Commelina benghalensis, Ageratum cony zoides, Phyllanthus maderaspatensis, Digeria arvensis and Cynotis cucullata, sedges were Cyperus rotundus and Cyperus esculentus*. The variety DGGV-2 was sown on 17th June of 2021. Among the treatments, weed free recorded significantly higher number of pods (13.8), 100 seed weight (5.48g), grain yield (860 kg/ha), higher weed control efficiency (100%) and lower weed biomass (0.7g m^{-2}) than other treatments except hand weedingtwice at 20 and 40 DAS (12.8, 5.25g, 796 kg/ha, 82.2% and 2.8 g/0.5m^2, respectively). However, all yield parameters and grain yield were on par with propaquizafop 33.3 g + imazethapyr 50 g/ha (12.4, 5.13g,713 kg/ha of number of pods/plant, 100 seed weight and grain yield, respectively). Among the herbicides, propaquizafop 33.3 g + imazethapyr 50 g/ha recorded significantly higher number of pods (12.4), 100 seed weight (5.13g), grain yield (713 kg/ha), and weed control efficiency (81.40%) than other herbicides. However, it was on par with imazethapyr 55 g/ha in terms of weed biomass (3.6 g/0.5 m^2). All the herbicides tried were having phytotoxicity less than 4 (in scale of 1-10). The results of this study indicated that e propaquizafop 33.3 g + imazethapyr 50 g/ha PoE can be used for effective control of weeds with higher yield in greengram.

Evaluation of herbicides for weed control in irrigated maize and its impact on soil microflora and their residual effect on succeeding blackgram

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Maize is one of the pivotal food grain crop in the world and its productivity is low in India as compared to the world productivity, which can be attributed by several limiting factors. Among all, weed infestation and improper weed management pose severe yield reduction in maize. Weeds are the most destructive crop pest, which interfere the crop growth by competing the growth limiting factors. Controlling of weeds in maize during the critical period assumes great importance for realizing higher yield. Unavailability of labour in time necessitated the use of herbicides in maize. Pre-emergence herbicides do not control the late-emerging weeds. Likewise, herbicides used as post-emergence are applied after 20-25 DAS permitting competition upto 20-25 days. Hence, sequential application of herbicides provides broad-spectrum weed control during a critical period of the crop. Moreover, continuous application of voluminous herbicides may affect the soil environment and herbicide residue may affect the succeeding crop. For sustained crop production, applied herbicides should have least adverse impact on soil health, especially on microorganism. Hence, the study was undertaken during *Kharif* 2019 to evaluate the sequential application of herbicides on maize and its impact on soil microorganisms and their residual effect on succeeding blackgram. In weed management treatments, weed free and unweeded check were taken as control. Herbicide treatments include: pre-emergence application (PE) of atrazine 0.25 kg/ha followed by (*fb*) hand weeding; pendimethalin 1 kg/ha PE *fb* hand weeding; atrazine 0.25 kg/ha *fb* post-emergence application (PoE) of tembotrione 120 g/ha; pendimethalin 1 kg/ha *fb* tembotrione 120 g/ha; atrazine 0.25 kg/ha *fb* halosulfuron methyl 90 g/ha PoE; pendimethalin 1 kg/ha PE *fb* halosulfuron methyl 90 g/ha PoE. Hand weeding was given at 25 days after seeding (DAS). During *Rabi* season, blackgram was raised on the same soil to assess the residual toxicity of different herbicides. The lowest weed density (48.67 number/m^2), weed biomass (41.53 g/m^2) and highest weed control efficiency (89.21%) and grain yield (6.63 t/ha) were recorded in the sequential application of atrazine 0.25 kg/ha PE *fb* tembotrione 120 g/ha PoE in maize crop. Microbial population is the most important ecological indicator, which reflects soil health. With regards to different weed management treatments on the rhizosphere, the highest soil microbial population, *viz.* bacteria, fungi and actinomycetes were observed under unweeded check and weed free check. Numerically lesser microbial population was recorded under all the herbicide applied plots during the initial stage. The effect of pre-emergence herbicides on microbes was not-significant. Post-emergence application of herbicides significantly reduced the population of bacteria and fungi, however no significant impact on actinomycetes was observed. At 60 DAS, gradual buildup of microbial population in all the herbicide applied plots was registered and attained equal level to untreated plots and showed non-significant effect for all microbial populations. In succeeding blackgram, there is no significant difference in germination, plant height and dry matter production of blackgram due to the residual effect of the herbicides applied to the preceding maize. It can be inferred that atrazine 0.25 kg/ha PE *fb* tembotrione 120 g/ha PoE was effective in weed control and was safe to the soil environment and succeeding crop.

Efficacy of newer post-emergence herbicides for weed management in greengram

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Greengram is an important *Kharif* pulse crop of Rajasthan for rainfed conditions. In *Kharif* season, weeds cause great losses than either insects or diseases. Weeds compete for water, nutrients and space and cause up to 45 per cent loss in greengram. Intermittent rains, unavailability of timely labour during rainy season has caused the problem of weed competition in crops up to 30-40 days after sowing (DAS), being the critical period for crop weed competition. It is imperative to develop cheaper methods of weed control with effective herbicides helps in reducing the weed population without much adverse effect on the crop productivity. Therefore, an experiment was conducted during *Kharif* 2020 at ARS, Ummedganj, Kota, with eight treatments, *viz.*, weedy check, weed free check, hand weeding twice at 20 and 40 days after seeding (DAS), imazethapyr 55g/ha, fluazifop-p-butyl 250 g/ha, propaquizafop 2.5% w/w 33.3 g/ha + imazethapyr 3.75% w/w ME 50 g/ha, acifluorfen-sodium 16.5% EC 140 g/ha + clodinafop-propargyl 8% EC 70 g/ha, fomesafen 11.1% w/w 220 g/ha + fluazifop-p-butyl 11.1% w/w 220 g/ha. The experiment was laid out in randomize block design and replicated thrice. Among herbicides tested, fomesafen 11.1% 220 g/ha + fluazifop-p-butyl 11.1% 220 g/ha (ready-mix) at 20 DAS recorded maximum and significantly higher pods/ plant, grain yield and net returns being at par with propaquizafop 2.5% 33.3 g/ha + imazethapyr 3.75% ME 50 g/ha (ready-mix) at 20 DAS and acifluorfen-sodium 16.5% EC 140 g/ha + clodinafop-propargyl 8% EC 70 g/ha (ready-mix) at 20 DAS, respectively over rest of herbicidal treatments. Minimum and significantly lower weed density and biomass was recorded with weed free check followed by hand weeding twice. Among herbicides, fomesafen 11.1% 220 g/ha + fluazifop-p-butyl 11.1% 220 g/ha (ready-mix) at 20 DAS recorded minimum and significantly lower weed density at 30, 60 DAS and at harvest being at par with propaquizafop 2.5% 33.3 g/ha + imazethapyr 3.75% ME 50 g/ha (ready-mix) at 20 DAS and acifluorfen-sodium 16.5% EC 140 g/ha + plodinafop-propargyl 8% EC 70 g/ha (ready mix) at 20 DAS over rest of herbicides treatments. Similarly, maximum weed control efficiency was also recorded in weed free check followed by hand weeding twice at 20 and 40 DAS. Among herbicides application of fomesafen 11.1% 220 g/ha + fluazifop-p-butyl 11.1% 220 g/ha (Ready mix) at 20 DAS recorded maximum and significantly higher weed control efficiency being at par with propaquizafop 2.5% 33.3 g/ha + imazethapyr 3.75% ME 50 g/ha (ready-mix) at 20 DAS and acifluorfen-sodium 16.5% EC 140 g/ha + clodinafop-propargyl 8% EC 70 g/ha (ready-mix) at 20 DAS over rest of herbicides treatments. The weed population (species as well as density) was not uniform in the experimental field.

Effect of integrated weed management on weed control and yield of summer greengram

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A field experiment was carried out during summer 2016 at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to study the effect of integrated weed management on weed control and yield of summer greengram (*Vigna radiata* L. Wilczek). Twelve integrated weed management treatments, *viz.*, T_1 : pre-emergence application (PE) of pendimethalin 1.0 kg/ha, T_2 : pendimethalin 1.0 kg/ha PE + intercultivation (I.C.) followed by (*fb*) hand weeding (H.W.) at 30 days after seeding (DAS), T_3 : post-emergence application (PoE) of quizalofop-p-ethyl 50 g/ha 15-20 DAS *fb* I.C. *fb* H.W. at 30 DAS, T_4 : quizalofop-p-ethyl 75 g/ha PoE 15-20 DAS, T_5 : pendimethalin 1.0 kg/ha PE *fb* quizalofop-p-ethyl 75 g/ha PoE 15-20 DAS, T_6 : quizalofop-p-ethyl 100 g/ha PoE 15-20 DAS, T_7 : imazethapyr 75 g/ha PE *fb* I.C. *fb* H.W. at 30 DAS, T_8 : pendimethalin 1.0 kg/ha PE *fb* imazethapyr 75 g/ha PoE at 15-20 DAS *fb* I.C. *fb* H.W. at 30 DAS, T_9 : imazethapyr 100 g/ha PoE at 15-20 DAS *fb* I.C. *fb* H.W. at 30 DAS, T_{10} : I.C. *fb* H.W. at 20 and 40 DAS, T_{11} : weed free and T_{12} : unweeded control were laid out in a randomised block design with three replications. Greengram variety Gujarat Mung 4 was used. The soil of experimental plot was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potassium status. Different integrated weed management treatments tested in this experiment had significant effect on seed and stover yield of greengram. Weed free recorded significantly higher seed (1181 kg/ha) and stover yield (3296 kg/ha) and it was statistically at par with T_8 (Pendimethalin 1.0 kg/ha PE *fb* Imazethapyr 75 g/ha PoE at 15-20 DAS *fb* I.C. *fb*H.W. at 30 DAS), which were significantly superior than rest of the treatments. Beside weed free, pendimethalin @ 1.0 kg/ha PE *fb* imazethapyr 75 g/ha PoE at 15-20 DAS *fb* I.C. *fb*H.W. at 30 DAS recorded higher plant height, seed yield, stover yield, net return, BCR and weed control efficiency as well as lower weed index and dry weight of weeds. I It is concluded that maximum seed yield and effective weed control in greengram can be achieved by maintaining weed free condition throughout crop growth period where labours are easily available. Under constraint of labour availability, maximum seed yield and net profit can be achieved with pendimethalin @ 1.0 kg/ha PE *fb* Imazethapyr @ 75 g/ha PoE 15-20 DAS *fb* interculture *fb* by hand weeding at 30 DAS.

Weed seed bank as affected by different mulches and herbicides in summer greengram

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Greengram [*Vigna radiata* (L.)] is the third major pulse crop of India followed by chick pea and pigeon pea. The competition offered by weeds is one of the major constraints in realizing full yield potential of this crop. A soil weed seed bank includes all viable seeds and vegetative propagates present on and in the soil which might be originated from the recent seed rain or previous years. Currently, weed management strategies have mainly focused on chemicals leading to evolution of herbicide resistant weeds and serious environmental issues. On-farm burning of surplus crop residues adds to environmental pollution. Retaining crop residues as surface mulch as an alternative to its burning could be useful for reducing weed populations. Integrated weed management (IWM) is an approach to manage weed seed bank using various control methods. The present study included combination of different mulches and weed control treatments with the aim to prevent weed emergence and to reduce the soil weed seed bank. The field experiment was carried out on a sandy loam soil during summer 2021 and 2022 at Punjab Agricultural University, Ludhiana, India. The study was laid out in a split plot design keeping four mulch levels (no mulch, paddy straw mulch, wheat straw mulch and sugarcane trash mulch at 8 t/ha) in main plots and four weed control treatments (weedy check, pendimethalin 750 c, quizalofop-ethyl at 37.5 and propaquizafop at 75 g/ha) in sub-plots, and replicated three times. At 0-2.5 cm soil depth, as compared to initial seed bank during 2021 and 2022, the viable grass weed seeds were 14.81% and 9.20% higher under no mulch. Different mulches reduced grass weed seed bank by 23.60-33.90% in 2021 and by 32.90-48.80% in 2022. Among weed control, weedy check had 19.10 and 19.20% higher weed seeds than initial, while herbicide treatments reduced seed bank by 24.45-37.27% during 2021 and 43.1-51.2% during 2022. In case of broad-leaved weeds, different mulches recorded 3.00-7.71% and 15.12-24.65% lower seeds while no mulch had 16.23-23.54% higher viable weed seeds as compared to initial seed bank. Among weed control, pendimethalin had 22.64% and 47.90% lower while other weed control treatments had 4.50-12.40% and 1.41-10.23% higher viable weed seeds as compared to initial. At 2.5-5 cm soil depth, as compared to initial seed bank during 2021 and 2022, the viable grass weed seeds were 11.93% and 14.20% higher under no mulch. Different mulches reduced grass weed seed bank by 19.66-31.23% in 2021 and by 32.20-41.50% in 2022. Among weed control, weedy check had 24.43% and 27.40% higher weed seeds than initial seed bank, while herbicide treatments reduced seed bank by 23.80-38.43% during 2021 and 39.50-49.91% during 2022. In case of broad-leaved weeds, different mulches recorded 6.60-17.20% and 16.25-29.11% lower seeds while no mulch had 25.90-36.80% higher viable weed seeds as compared to initial. Among weed control treatments, pendimethalin had 25.40% and 36.00% lower seeds while other weed control treatment had 4.60-11.30% and 4.00-11.80% higher viable weed seeds as compared to initial number. The present study highlights the importance of integrated methods including mulch and herbicide as components in determining the characteristics of weed seed bank in soil.

Response of chickpea to weed control practices

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Chickpea (*Cicer Arietinum L.*) is an important legume crop grown in tropical and sub-tropical regions of the world and it has high protein in its seeds. India is the largest producer of this pulse contributing to around 70% of the world's total production. Severe crop losses have been observed due to weeds in chickpea because of short statured growth habit and slow initial growth. Weed infestation is reported to cause yield losses to the extent of 75% in chickpea and critical period for crop weed competition is around 30 to 60 days after seeding (DAS). Hand weeding and inter-culturing are effective, but not feasible due to poor soil physical condition and unavailability of labour. In this context, integration of herbicides with hand weeding and inter-culturing can play vital role in management of weeds. A field study was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada during *Rabi* season of 2019-20. The soil of experimental field was loamy sand in texture with low in organic carbon and low in available nitrogen, medium in available phosphorus and high in available potassium having pH value of 7.48. In the experimental field, predominant weed flora was: *Eragrostis major, Eleusine indica, Dactyloctenium aegyptium and Asphodolus tenuifolius and Chenopodium album*. The experiment consisting twelve treatment combinations comprising two levels of nitrogen *i.e.* 15 and 30 kg nitrogen/ha and six treatments of weed control practices, *viz.*, W1 : weed free, W2 : unweeded, W3 : pre-emergence application (PE) of pendimethalin 0.75 kg/ha, W4 : post-emergence application (PoE) of imazethapyr 75 g/ha at 25 DAS, W5 : pendimethalin 0.75 kg/ha PE followed by (*fb*) interculturing at 30 DAS *fb* hand weeding at 45 DAS and W6 : imazethapyr 75 g/ha PoE at 25 DAS *fb* hand weeding at 45 DAS were evaluated in randomized block design with factorial design, replicating thrice. Weed free recorded maximum chickpea plant height, dry matter accumulation per plant, number of pods per plant, 100- seed weight, seed and stover yield per plant, grain and stover yield being at par with pendimethalin 0.75 kg/ha PE *fb* interculturing at 30 DAS *fb* hand weeding at 45 DAS. Weed free treatment recorded minimum weed index and maximum weed control efficiency which was closely followed by pendimethalin 0.75 kg/ha PE *fb* interculturing at 30 DAS *fb* hand weeding at 45 DAS.

Integrated weed management: A comprehensive and effective approach of weed management in pluses

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Weeds are unwanted and undesirable plants that interfere with utilization of land and water resources and thus adversely affect crop production and human welfare. Farmers have been struggling with weeds in their fields since the beginning of agriculture. Weed management accounts for nearly one third of total cost of production of field crops. Yield losses in crops due to weeds depend on several factors such as weed emergence time, weed density, type of weeds and crops, *etc*. Integrated weed management is a method whereby all economically, ecologically and effective methods are used in an integrated way to keep the weeds below the economic threshold levels, keeping in the foreground the conscious employment of natural limiting factors (FAO). Pulses are the important crop after cereals and are the cheapest source of dietary protein. After the Green revolution, the production of pulses in India remained stagnant over the years due to various biotic and abiotic stresses. Weeds are the predominant biological constraint in pulse production due to the slow initial growth of the crop. In general, critical period of weed competition for short duration pulses is up to 30 days and for long duration pulse crops it is up to 60 days. Three major types of weeds, *viz.* grasses, broad-leaved weeds and sedges were found in association with pulses. Intensity of weed infestation varies with agroecological conditions and crop management practices followed. Weed management in pulses is essential to bring the weeds below the threshold level to maximize the seed yield and quality. Strategies' of weed management depends on the weed competition, types of weeds present and weed control method adopted. A system approach is necessary to maintain the weed population below the economic threshold level thereby reducing the yield loss. Integrated weed management (IWM) which has been proved to be more effective than any single method in alleviating the build-up of weeds in pulse crop.

TECHNICAL SESSION 7

Weed management in rice-based cropping system

Weed management in dry direct-seeded rice

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Rice (*Oryza sativa* L.) is an important food crop of India contributing 45% of the total food grain production. Direct-seeding eliminates the need of raising, maintaining and subsequent transplanting of seedlings, besides it is cost effective, can save water through earlier rice crop establishment and allows timely sowing of wheat. However, direct-seeding is subjected to greater weed competition than transplanted rice. Weeds can reduce the grain yield of dry-seeded rice (DSR) by 75.8%. Hence, this experiment was conducted at Regional Research Station, Anand Agricultural University, Anand during *Kharif* season of the year 2021 on loamy sand soil with twelve treatments and three replications. The objective was to identify an effective and economical way to manage complex weed flora in direct-seeded rice. In general, dominancy of dicot weed (47.4%) was observed in the experimental field during crop period wherein, major weeds observed were *Dactyloctenium aegyptium* (20.8%), *Digitaria sanguinalis* (6.93%), *Echinochloa colona* (6.93%), *Echinochloa crus-galli* (4.11%) in monocot weeds category whereas, *Phyllanthus niruri* (18.2%), *Oldenlandia umbellata* (15.6%), *Trianthema monogyna* (8.66%) and *Amaranthus viridis* (2.60%) in dicot weed category and *Cyperus rotundus* (7.14%) in sedges category. Early post-emergence application (EPoE) of triafamone 20% + ethoxysulfuron 10% WG (44.0+22.5 g/ha) followed by (*fb*) mechanical weeding at 30 days after seeding (DAS) recorded maximum weed control efficiency (98.4%) which was closely followed by mechanical weeding at 20 and 40 DAS (92.3%), bispyribac-sodium 25 g/ha EPoE *fb* HW at 30 DAS (90.0%) and penoxsulam 1.02% + cyhalofop-butyl 5.1% OD 120 g/ha EPoE *fb* HW at 30 DAS (89.5%) at 60 DAS. Among all the treatment, mechanical weeding at 20 and 40 DAS registered significantly higher and grain (3.12 t/ha) and straw (5.17 t/ha) yield and closely followed by pre-emergence application (PE) of pretilachlor 30% + pyrazosulfuron-ethyl 0.75% WG (600+15 g/ha) *fb* HW at 30 DAS, penoxsulam 1.02% + cyhalofop-butyl 5.1% OD 120 g/ha EPoE (PM) *fb* HW at 30 DAS, triafamone 20% + ethoxysulfuron 10% WG (44.0+22.5 g/ha) EPoE (PM) *fb* mechanical weeding at 30 DAS and bispyribac-sodium 10% SC 25 g/ha EPoE *fb* HW at 30 DAS with higher B:C.

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Weed diversity effect of crop establishment methods and diversified rice-based cropping systems

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The adoption of climate resilient practices especially direct-seeded rice (DSR) and zero tillage (ZT) is being increased in farmers' fields, because of benefit of saving labour, water, planting time and easily availability of machine. However, the higher weed infestation in these practices poses great challenges to its sustainability. The DSR and zero tillage practices affect the weed diversity, as changes in crop management practices changed the weed density and diversity. Hence, a field experiment was carried out in RBD with ten treatments, *viz.*, (i) transplanted puddled rice (TPR)– convectional tillage wheat (CTW), (ii) rice (TPR)-wheat zero tillage wheat (ZTW),(iii) PTR- zero tillage mustard (ZTM)- conventional tillage maize+ mung bean (CTM+Mu), (iv) PTR- CT Potato+ winter maize (WM),(v) PTR-wheat (ZTW)-ZTMu, (vi) DSR-ZTW- ZTMu,vii)DSR-ZTM-ZTMu, (viii) DSR-CTP-ZTMu, (ix) DSR-CTP+WM,(x) DSR-mustard (ZTM)-CT-M+Mu during 2020-22,with objective to determine the sustainability of diversified rice-based cropping systems and weed diversity under climate change scenario. The weed sampling was done from randomly selected three spot of plot size of 20 x 5 m before the weed management practice. Species wise weeds were separated and counted. A total of twelve weed species were recorded in summer season, *viz.*, *Cyperus rotundus, Cyperus, difformis, Cynodon dactylon, Echinocloa colona, E. crusgalli, Eleusine Indica, Digitaria Sangunalis, Leptochloa Chinesis, Caesulia axillris. Sphenoclea zeylanica, Ludwigia octovalis, Ammania baccifera, Saggitaria guyanensis* in Rainy/*Kharif* season; eleven weed species *Cyperus rotundus, Cydodon dactylon, Polypogon monspeliensis, Chenopodium album, Cannabis sativa, Circium arvense, Sonchus arvensis, Euphorbiahelioscopia, Gnaphalium, Annagalis arvensis, Rumex dentatus,* in winter/ *Rabi* season and sixweed species, *Cyperus rotundus, Cydodon dactylon, Digitaria Sangunalis, Eleusine Indica, Amaranthus viridis, Physalis minima*. The DSR had higher weed density and weed richness but comparatively lower Shannon index than TPR. Comparatively higher Importance Value Index (IVI) of *Cyperus rotundus*, *Cynodon dactylon* and *Setaria glauca* in DSR than puddle rice irrespective of cropping systems. During winter season higher IVI of *Circium arvensis* was recorded in ZTW, while, higher IVI of *Chenopodium album* was in CTW and comparatively higher weed diversity in CTW than ZTW. During summer season, higher IVI of *Cyperus rotundus*. Crop diversification had little impact on weed diversity; DSR after summer mung recorded the lower *Cynodon dactylon* than DSR after fallow field in summer.

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Tillage and weed management practices influence on weed dynamics, growth and yield of direct-seeded rice in rice-wheat-greengram cropping system

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Weeds are major production constraints in crops and cropping systems. Adoption of different tillage practices further changes the weed flora. However, currently, resource availability is meagre, thus the adoption of conservation tillage-based practices plays a crucial role. But, the diversity and severity of weeds are much more pronounced under conservation tillage-based system. Hence, a long-term field experiment was initiated at ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh, India during *Kharif* 2012 to find out the effect of tillage and weed management practices on weed dynamics, growth and yield of direct-seeded rice in rice-wheat-greengram cropping system. The experiment was laid out in a split-plot design and replicated thrice during 2022 on rice, where tillage was assigned to main plots [conventional tillage (CT) and zero-tillage with full crop residues (ZTR)] and weed management practices in subplots [W_1-weedy check (control), W_2-recommended herbicide (RH), W_3-integrated weed management (IWM) and W_4-herbicide rotation (HR)], altogether, there were eight treatment combinations. The experimental field was dominated by major grasses like *Dinebra retroflexa* (Vahl) Panz., *Echinochloa colona* (L.) Link, *Eleucine indica* (L.) Gaertn., and *Digitaria sanguinalis* (L.) Scop., broad-leaved weeds like *Alternanthera paronychoides* A. St.-Hil. and *Physalis minima* (L.), whereas *Cyperus iria* (L.) was the dominant sedge. The higher density and biomass of *D. retroflexa, E. colona, D. sanguinalis* and *A. paronychoides* was recorded with ZTR than CT. However, *C. iria* population was more with CT than that of ZTR. Overall, weed control efficiency was higher in CT over ZTR. Among weed management practices, sequential application of pretilachlor+pyrazosulfuron at 615 g/ha PE followed by (*fb*) bispyribac-sodium 25 g/ha as post-emergence (PoE) *fb* hand weeding at 40 days after sowing (DAS) (IWM) recorded the lowest weed density and biomass with higher weed control efficiency followed by pretilachlor+pyrazosulfuron at 615 g/ha PE *fb* cyhalofop+penoxsulam at 135 g/ha PoE. The lower weed density and weed biomass helped the crop to produce more growth parameters (tillers, leaf area index, total dry matter *etc*.) and attain better yield attributes (effective tillers, panicle length, sound grains *etc*.) which led to higher grain and straw yield under CT over ZTR. Among weed management practices, lower weed density and biomass was with IWM [pretilachlor+pyrazosulfuron at 615 g/ha PE *fb* bispyribac-sodium at 25 g/ha PoE *fb* hand weeding at 40 DAS (IWM)] helped in higher growth parameters and yield attributes resulting in higher grain and straw yield. The plots with herbicide rotation [pretilachlor+pyrazosulfuron at 615 g/ha PE *fb* cyhalofop+penoxsulam at 135 g/ha PoE] was the next best treatments but was inferior to IWM and superior to RH (pretilachlor+pyrazosulfuron at 615 g/ha PE *fb* bispyribac-sodium at 25 g/ha PoE) and weedy check. The interaction of tillage practices and weed management practices was significant where the adoption of CT with IWM obtained lesser weeds density and weed biomass, higher rice tillers, LAI and total dry matter with more numbers of effective tillers, longer panicles, more sound grains with higher grain and straw yield.

Persistence of clomazone in transplanted rice under open field condition

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Rice is the staple food for two-thirds of the world's population. This simple grain has been a popular life-sustaining food for thousands of years because it is nutritious, versatile, economical, easy to prepare and tastes good. Rice is cultivated in more than 100 countries and on every continent except Antarctica.It is generally considered a semi-aquatic annual grass plant. About 20 species of the genus *Oryza* are recognized, but nearly all cultivated rice is *Oryza sativa* L. About 80% of the world's rice is grown by small-scale farmers in low-income and developing countries. In all the small holder systems, weeds (*Panicum* spp., *Cynodon dactylon, Echinochloa crus-galli, Phyllanthus niruri, Echinochloa colona, Cyperus difformis, Cyperus iria, Ludwigia parviflora, Phyla nodiflora*) are one of the major biological constraints to rice production. Weeds compete with the rice for soil, water, and space. Weed control is important to prevent losses in yield and production costs, and to preserve good grain quality of paddy. Many cultural, biological, physical and chemical practices affect the composition and intensity of weeds in rice. Weeds can be controlled with pre-emergence or post-emergence herbicides. The pre-emergence herbicides, *viz.* butachlor 2 lit/ha, pendimethalin 2.5 lit/ha, anilophos 1.25 lit/ha and thiobencarb 2 lit/ha are being used specially for controlling the weeds (*Echinochloa crus-galli, Echinochloa colona, Cyperus difformis, Cyperus iria, Ludwigia parviflora and Eclipta alba*) in nursery stage. It is necessary to determine the residue retention of applied clomazone in paddy grain, husk, straw and soil at the time of harvest. The present experiment was carried out at NEB Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *Kharif* 2017-18 season. The trial was conducted in a Randomized Block Design in transplanted rice (*HKR-47*) with three treatments and replications. The pre-emergence application (PE) of clomazone at standard dose of 500g/ha and double dose of 1 kg/ ha applied at two days after sowing (DAS). 750 plants per plot were maintained in three different replications. Residue analysis of clomazone in paddy grain, husk, straw and soil was carried out and the samples were fortified at 0.05, 0.25 and 0.5 ppm levels. Result of the recovery study ranged from 86 to 108% in all the commodities. Paddy grain, paddy husk, paddy straw and soil samples were collected at 105 days after the last application (at the time of harvest). The samples were then gone through extraction procedure (QuEChERS method for pesticide residue analysis) and analysed on ABSciex make LC-MS/MS; (Model: UPLC- acquity UPLC, Waters and MS-API 3200), Triple quadrupole with positive polarity. The result showed in the residues of clomazone was below determination level (0.05 mg/g) in paddy grain, husk, straw and soil at harvest (*i.e.* 105 days after application).

Practices of weed management under direct-seeded rice in coastal deltaic ecosystem

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A field experiment was conducted at Pandit Jawaharlal Nehru College of Agricultural and Research Institute, Karaikal, U.T. of Pondicherry during Thaladi season (from September 2019 to January 2020) with the treatment combination of three levels of cultivars in main plot and five levels of weed management practices in the sub plots replicated thrice in spilt plot design to evaluate the weed management practices for different rice cultivars under direct-seeded rice in coastal deltaic ecosystem. Three cultivars used were: ADT 46, CO 52 and IWP. The five weed management treatments tested were: pre-emergence application (PE) of pendimethalin 1 kg/ha, post-emergence application (PoE) of bispyribac-sodium 0.02 kg/ha, sequential application of pendimethalin 1 kg/ha PE followed by (*fb*) bispyribac-sodium 0.02 kg/ha PoE, hand weeding twice at 20 and 40 days after seeding (DAS) and unweeded control. The weed spectrum was dominated with 69.70% of broad-leaved weeds, grasses (19.39%) and sedges (10.91%). Significantly highest grain yield (3759 kg/ha) was recorded with ADT 46 followed by CO 52 (3050 kg/ha) and IWP (2580 kg/ha). Among weed management treatments, the higher grain yield (3734 kg/ha) was recorded with sequential application of pendimethalin PE fb bispyribac – sodium PoE which is on par with hand weeding twice (3538 kg/ha). The next highest grain yield was due to bispyribac – sodium PoE alone (3186 kg/ha) and it was on par with pendimethalin PE alone (2977 kg/ha). All weed management treatments have registered significantly higher than that of unweeded control (2213 kg/ha).The rice yield reduction was 51.9 per cent due to weeds in unweeded control as compared to various applications of weed management practices. The highest gross return (¹ 57271/ha), net return (¹ 28176/ha) and the B: C ratio (1.97) was obtained with the combination of ADT 46 and pendimethalin PE fb bispyribac – sodium PoE. Next highest was with ADT 46 under hand weeding twice which registered the gross return of ¹ 51833/ha. The highest energy output, energy use efficiency and energy productivity of 67558 MJ/ha, 5.35 and 0.36 kg/MJ, respectively was registered by ADT 46 with pendimethalin PE fb bispyribac – sodium PoE which was on par with hand weeding twice. The lowest energy output (28242 MJ/ha), energy use efficiency (2.31) and energy productivity (0.16 kg/MJ) were registered under unweeded control.

Evaluation of integrated weed management practices in aerobic rice

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A field experiment was carried out at wetland farm, Tamil Nadu Agricultural University, Coimbatore, during March-July, 2022 to evaluate different integrated weed management practices in aerobic rice. The field experiment was laid in randomized block design with nine treatments replicating thrice. The texture of experimental field soil was clay loam. The nutrient status of the field was low in available nitrogen, medium in available phosphorus and high in available potassium. Treatments were: integration of pre-emergence application (PE) of pendimethalin 1.0 kg/ha with hand weeding twice at 25 and 45 days after seeding (DAS) (T_1), pyrazosulfuron ethyl 30 g/ha PE with hand weeding twice (T_2) or mechanical weeding (T_3) at 25 and 45 DAS, early post-emergence application (EPoE) of bispyribac-sodium 40 g/ha with one hand weeding (T_4) or mechanical weeding (T_5) at 45 DAS and pyrazosulfuron-ethyl 30 g/ha PE with bispyribac sodium 40 g/ha EPoE and one mechanical weeding at 45 DAS (T_6). These were compared with hand weeding twice (T_7), mechanical weeding twice (T_8) at 25 and 45 DAS and a control (weedy check). The predominant weed flora of the experimental field consisted of grasses and broad-leaved weeds. The major grassy weeds were: *Echinocloa colona* and *E. crus-galli* and broad-leaved weeds were: *Portulaca oleracea* and *Corchorus olitorius*. Pendimethalin 1.0 kg/ha PE followed by hand weeding twice at 25 and 45 DAS showed effective weed control and recorded lower weed density and dry biomass, resulting in higher weed control efficiency. This was comparable with the integration of pyrazosulfuron-ethyl 30 g/ha PE with bispyribac sodium 40 g/ha EPoE and one mechanical weeding on 45^{th} day. The sequential application of pyrazosulfuron ethyl 30 g/ha PE and bispyribac sodium 40 g/ha EPoE with one mechanical weeding at 45 DAS (T_6) recorded higher rice growth parameters, nutrient uptake and also yield attributing characters, while lower growth and yield attributes were recorded in weedy check due to severe competition for growth factors from weeds. The higher rice grain yield (3544 kg/ha), straw yield (4717 kg/ha), gross returns (63,796 ¹ /ha), net returns (29,244 ¹ /ha) and B:C ratio (1.85) were obtained with the integrated weed management practice that had sequential application of pyrazosulfuron ethyl 30 g/ha PE and bispyribac sodium 40 g/ha EPoE with one mechanical weeding at 45 DAS (T_6). The lower grain yield (1498 kg/ha) and straw yield (2452 kg/ha) were recorded with weedy check. It can be concluded that, the sequential application of pyrazosulfuron ethyl 30 g/ha PE with bispyribac sodium 40 g/ha EPoE and a mechanical weeding on 45 DAS resulted in efficient weed control throughout the crop period and increased weed control efficiency, which in turn resulted in higher grain yield and B:C ratio. Considering labour scarcity, this weed management practice could be a viable option for aerobic rice cultivation.

Weed management in aerobic rice

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A field experiment was conducted during summer season at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to study the weed management in aerobic rice (*Oryza sativa* L.) under South Gujarat conditions. Total twelve treatments combinations, *viz.*, pre-emergence application (PE) of butachlor 1.25 kg/ha (T_1), pendimethalin 1.00 kg/ha PE (T_2), pretilachlor 0.75 kg/ha PE (T_3), aniloguard 0.5 kg/ha PE (T_4), post-emergence application (PoE) of 2,4-D (Ethyl ester) 1.00 kg/ha at 20 to 25 days after seeding (DAS) (T_5), T_1 + hand weeding at 40 DAS (T_6), T_2 + hand weeding at 40 DAS (T_7), T_3 + hand weeding at 40 DAS (T_8), T_4 + hand weeding at 40 DAS (T_9), T_5 + hand weeding at 40 DAS (T_{10}), un weeded control (T_{11}), weed free (by hand weeding at 20, 40 and 60 DAS) (T_{12}) were evaluated in randomized block design with 3 replications. The experimental field was infested by number of weed species comprising of monocot weeds, *viz.*, *Echinochloa crusgalli* (L.), *Echinochloa colunum* L., *Cynodon dactylon* (L.), *Eichhornia crassipes*, *Dactyloctenium agegyptium* and *Bracharia spp*.; major dicot weeds, *viz.*, *Alternanthera sessilis*, *Digera arvensis*, *Euphorbia hirta* L. and *Physalis minima* L. Treatments, *viz.*, T_1 + hand weeding at 40 DAS (T_6), T_2 + hand weeding at 40 DAS (T_7), T_3 + hand weeding at 40 DAS (T_8) and T_4 + hand weeding at 40 DAS (T_9) were most effective with the lowest weeds biomass, higher weed control efficiency and lower weed index., The unweeded control recorded the highest weeds biomass and higher weed index at harvest. almost of the growth and yield attributes, *viz.*, plant height, number of tillers/plant, number of panicles/m^2 and number of grains / panicle were significantly influenced by tested weed management treatments. Higher values of all the growth and yield attributing characters and the highest grain and straw yields were recorded under weed free maintained by hand weeding at 20, 40 and 60 DAS (T_{12}) and it was at par with T_1 + hand weeding at 40 DAS (T_6), T_2 + hand weeding at 40 DAS (T_7) and T_3 + hand weeding at 40 DAS (T_8). It can be concluded that higher profitable yield of summer aerobic rice variety Jaya can be obtained by keeping the crop weed free either by hand weeding coupled with hoeing or by hand weedings twiceat 20 and 40 day after sowing. Pendimethalin 0.75 kg/ha PE followed by hand weeding at hoeing at 40 days after sowing may be used under labour scarce situation.

Studies on effective herbicidal weed management practice in direct seeded rice under Western Ghat zone

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In direct seeded rice (DSR) cultivation, weeds pose the major constraint mainly due to absence of puddling in field. The yield loss due to weed interference is huge, may be up to 100%. In this perspective, the present experiment was conducted to find out the effective herbicidal weed management practice in mechanized DSR under western ghat zone. The dry weight and density of weeds were recorded at different growth stages and consequently herbicide efficacy was evaluated. The field trial was arranged as a randomized complete block design with tent weed control treatments replicated three times, the area of gross plot and net plot size was 4.00 x 3.00 m2, 3.60 x 2.60 m^2.Treatments included different rate of oxyflourfen, pyrazosulfuron ethyl as pre-emergence (PE), tank mixture application of metsulfuron methyl 10% + chlorimuron ethyl 10% in combination with bispyribac-sodium as early post-emergence (EPoE) and sequential application of pyrazosulfuron ethyl and pendimethalin as PE followed by bispyribac-sodium application as post-emergence. The herbicides were applied with a knapsack sprayer that delivered ~ 500 L/ ha spray solution through flat fan nozzles. For the weed-free treatment, two hand-weedings were done to maintain a weed-free situation. In the weedy control, no weeding was done. Experimental results revealed that pre-emergence (PE) herbicide effectively controlled the germination of grassy weeds. Application bispyribac-sodium as post-emergence (POST) following PRE herbicides (pyrazosulfuron ethyl or oxyflourfen) or as tank-mixture with metsulfuron methyl 10% + chlorimuron ethyl effectively reduced the density and biomass accumulation of diverse weed flora in DSR. Herbicidal treatments improved the plant height, yield attributes and grain yield (2.7 to 4.2 times) over weedy check. Differences in sensitivity values of weed dry matter and WCE across the crop growth stages also suggest that at 15, 30 and 60 days after sowing, herbicides most effectively controlled sedges, broad leaves and grasses, respectively. Based on the grain yield and herbicidal WCE, it can be concluded that the combined application of PRE application (EPoE) of pyrazosulfuron ethyl 10% WP 0.030 kg/ha at 8 DAS + application of bispyribac sodium 10% SC 0.030 kg a.i. /ha at 20 DAS or PRE application of oxyflourfen 23.5% EC 0.150 kg/ha at 2-3 DAS.+ POST application of bispyribac sodium 10% SC 0.030 kg a.i. /ha at 20 DAS as PRE followed by bispyribac-sodium as POST or tank-mixture of pyrazosulfuron ethyl + bispyribac sodium can effectively control different weed flushes throughout the crop growth period in DSR.The significantly higher grain yield was recorded in weed free check which was at par with treatment of pre-emergence application (early Post-emergence) of pyrazosulfuron ethyl 10% WP 0.030 kg/ha at 8 DAS + application of bispyribac sodium 10% SC 0.030 kg a.i. /ha at 20 DAS (42.00 q/ ha). Amongst the different treatments, weed free check has highest gross and net returns, and B:C ratio than rest of the treatments.The pre-emergence application of 100 g pyrazosulfuron ethyl 10% WP per hectare within two to three days after sowing and Post-emergence application of 100 milliliters of bispyribac sodium 10% SC per hectare at 20 days after sowing in 500 liters of water is recommended for effective control of weeds in drilled paddy for Western Ghat zone of Maharashtra. Next time try bispyribac + pyrazosulfuron combination as POE. It will save one application cost and unnecessary efforts.

Encapsulation of metsulfuron methyl for long season weed management in transplanted rice

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A field experiment was conducted at Department of Agronomy, Palli Siksha Bhavana, Visva Bharati, West Bengal during *Kharif* 2022 to study the effect of encapsulated metsulfuron methyl on long term weed management in transplanted rice. The experiment was laid out in Randomized Block Design with eleven treatments and replicated thrice. The treatments were, four different doses of encapsulated and commercial metsulfuron methyl, *viz.*, 2, 3, 4 and 5 g a.i/ha. These treatments were compared with farmers' practice of hand weeding twice at 20 and 40 days after transplanting, weed free check and unweeded control. Commercial and encapsulated herbicides were applied as pre-emergence. The rice variety MTU 7029 (Swarna) used for this course of investigation. The crop spacing 20 × 15 cm and plot size 5 × 4 m were maintained. Metsulfuron methyl active ingredient and Polymers were purchased from Sigma – Aldrich, Bangalore. Solvent evaporation method was used for encapsulating the metsulfuron methyl. The laboratory results revealed that, metsulfuron methyl is slightly positive charged and it took one litre of water for complete dissolving of 1.7-gram active ingredient. Optimum temperature required for the encapsulation is 40 ! and active ingredient to encapsulated formulation conversion ratio is 1:0.66. Encapsulation efficiency of encapsulated metsulfuron methyl is 72%. The field results revealed that, pre-emergence application of metsulfuron methyl efficiently controlled sedges, broad leaved weeds and some annual grasses. Pre-emergence application of encapsulated metsulfuron methyl doesn't allow the emergence of sedges and broad-leaved weeds up to 60 DAT.25 percent addition than the recommended dose of metsulfuron methyl does not produce any phytotoxicity to crops. Pre-emergence application of encapsulated metsulfuron methyl 2 g a.i ha^{-1} achieved equal weed control efficiency with recommended dose of commercial metsulfuron methyl 4 g a.i ha^{-1}. Application of encapsulated metsulfuron methyl controls the weeds even after critical period of crop weed competition led to reduce the early crop weed interference of subsequent crop. Moreover, application of metsulfuron methyl alone registered a satisfactory weed control in transplanted rice.

Study of herbicide mixtures, its effect on weed floristic composition and weed indices in wet direct seeded rice

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Spectacularly diverse weed flora in wet direct seeded rice is main constraint in rice cultivation. Hence, herbicide mixtures play a promising role in broad spectrum weed management despite of fact that some herbicides show temporary inimical effect like phytotoxicity, weed flora shift, herbicide resistance and detrimental effect on soil health. So, to study the effect of herbicide mixtures on weed floristic composition and weed indices, an experiment was conducted at Institute Research Farm of ICAR-National Rice Research Institute, Cuttack (Odisha) during *Kharif* season of 2017 with the test rice variety '*CR Dhan 203*'. The experiment was laid out in Randomized Block Design (RBD) with three replications and twelve treatments, *viz.* nine herbicide mixtures (azimsulfuron 50% DF+ bispyribac sodium 10% SC at (22+25) g/ha (T_1), flucetosulfuron 10% WDG (w/w) + bispyribac sodium 10% SC at (25+25) g/ha (T_2), penoxsulam 21.7% SC + cyhalofop-butyl 12% EC (w/v) at (25+100) g/ha (T_3), fenoxaprop-p- ethyl 6.7% EC (w/w) + ethoxysulfuron 15% WDG (w/w) at (50+15) g/ha (T_4), bispyribac sodium 10% SC+ ethoxysulfuron 15% WDG (w/w) at (25+15) g/ha (T_5), cyhalofop-butyl 12% EC (w/v) + ethoxysulfuron 15% WDG (w/w)at (75+15) g/ha (T_6), XR-848 benzyl ester 2.5% EC (w/v) + cyhalofop-butyl 12% EC (w/v) at (25+100) g/ha (T_7), flucetosulfuron 10% WDG (w/w)+ pretilachlor 30.7% EC at (25+500) g/ha (T_8), bensulfuron-methyl 0.7% + pretilachlor 7% GR at (70+700) g/ha (T_9)), single herbicide bispyribac sodium 10% SC at 30 g/ha (T_{10}), weed free (T_{11}) and weedy check (T_{12}).Among all the treatments, the weed free treatment (T_{11}) registered significantly highest yield (5.23 t/ha) and was at par with T_4, T_3 T_1 and T_2.The experimental trial was infested with diversified weed flora comprising the major weeds like *Echinochloa colona*, *Leptochloa chinensis*, *Cyperus difformis*, *C. iria*, *fimbristylis miliacea*, *Sphenoclea zeylanica*, *Marsilea quadrifolia* while other weed species *of Digitaria sanguinalis*, *Monochoria vaginalis*, *Commelina benghalensis*, *Ludwigia octavilis etc. were found.* Floristic composition of weeds showed broadleaf weeds abundance surpassed both grasses and sedges at most stages. Highest percentage of other weeds were registered at all growth stages *i.e.* 26.36% (30 DAS), 25.67% (60 DAS), 26.20% (90 DAS) and 22.00% (at harvest) while highest population of *Marsilea quadrifolia* (8.98%), *Echinochloa colona* (7.10%), *Cyperus difformis* (2.33%) and *Echinochloa colona* (0.28%) was found in 30, 60, 90 DAS and at harvest respectively.Different weed indices were varied as per the treatments. Among all treated treatments, at harvest stage, highest weed control efficiency (86%), weed persistence index (1.29) and weed management index (0.9)were recorded inplots treated with fenoxaprop-p ethyl + ethoxysulfuron at (50+15) g/ha. Highest herbicide efficiency index (4.48) and crop resistance index (12.24) were showed by penoxsulam + cyhalofop-butyl at (25+100) g/ha (T_3) and bispyribac sodium + ethoxysulfuron at (25+15) g/ha (T_5), respectively. Hence, fenoxaprop-p ethyl + ethoxysulfuron at (50+15) g/ha proved as best treatment in perspective of yield and weed indices. Also the treatments T_3 and T_5 were also found very effective weed management options in wet direct seeded rice and can be recommended for further use.

Efficient weed management approaches for aerobic rice cultivation

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Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population. Over ninety per cent of world rice is produced and consumed in Asia. As a consequence of competition among agricultural, industrial, environmental and domestic users led to scarcity of water and is going to threaten the sustainability of irrigated rice ecosystem. In this context aerobic rice production system plays a vital role in overcoming the problem related to water. Weeds are the greatest constraint in aerobic rice systems, resulting in 62.2 to 91.7 per cent yield losses. The absence of standing water makes aerobic rice more weed infested resulting in competition for resources with crop plants. The studies have revealed that the weed should be controlled within 20-60 days after sowing to reduce the yield losses. A major chunk of the cost in aerobic rice production is attributed to cost of weeding. High weed pressure in direct seeded rice lowers the economic return and in extreme cases rice cultivation results in a losing concern. This demands reappearance of physical, cultural and biological weed management combined with judicious application of herbicides based on a thorough understanding in the crop-weed ecology, known as integrated weed management. The present study was conducted to find out the suitable herbicide and manual weeding combinations simultaneously incorporated with different agronomic practices to provide a comprehensive integrated weed management system for aerobic rice situation. The trial was conducted during *Kharif,* 2020 at the Department of Rice, Tamil Nadu Agricultural University, Coimbatore. The treatments comprised of ten weed managementpractices, *viz.*, T_1 - Mulching with crop residue; T_2 - Mulching with crop residue followed by one Post-emergence herbicide application for 2nd flesh of weeds; T_3 - Mechanical weeding twice or thrice depending on weed intensity; T_4 - Mechanical weeding followed by Post-emergence herbicide application; T_5 - Chemical weed control; T_6 - Pre-emergence herbicide application *fb* one mechanical weeding; T_7 - Intercropping with *sesbania*; T_8 - Raised bed system of cultivation; T_9 - Weed free/two hand weeding and T_{10} - weedy check in replicated thrice in randomized block design. Based on the study, the results revealed that weed free cultivation recorded significantly higher grain yields and superior over other treatments. Among the treatments, mechanical weeding once followed by post herbicide application and only chemical weed control were statistically superior followed by mechanical weeding twice/thrice and Pre-emergence herbicide application followed by mechanical weeding showed promising performance. In the nutshell, among the different weed management approaches, mechanical weeding once followed by post-emergence herbicide application was found to be promising technology for effective weed control in aerobic rice eco system.

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Performance of different management strategies adopted by farmers in DSR in Yamunanagar of Haryana-A survey

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Rice (*Oryza sativa* L.) is one of the most important staple crop of India. Unlike other grains, rice is a versatile food that feeds more people worldwide and is relatively strong and resistant to a variety of physicochemical stressors. India has the largest area under rice cultivation in the world and is the second largest producer of rice after China. In recent times, yield stagnation along with excessive resource depletion has raised questions regarding sustainability of rice-wheat cropping system in India. Resource conserving and integrated farming in crop production are the need of time for mitigating climatic susceptibilities in the rice–wheat cropping system (RWCS) of India. Direct-seeded rice (DSR) offers a ray of hope in the form of efficient utilization of resources be it water or labor. But shifting from puddled anaerobic conditions to aerobic conditions leads to more weed emergence and has been a major bottleneck in wide scale adoption of DSR at farmer's field. Several studies have been conducted at research stations offering various weed management options in DSR. Herbicides offers the most practical and most adopted method for weed management option among farmers in paddy wheat cropping system where labor is major constraint owing to its better economics. Another major factor which influences adoption/non-adoption of DSR is the final yield which is sum total of all the management practices adopted by the farmers. Therefore, to assess the management strategies adopted by farmers, a field survey was conducted in Yamunanagar district of Haryana in *Kharif* 2022, covering 50 farmers. During the survey it was observed that most of the sowing (90%) was done as dry sowing (field preparation in dry conditions followed by sowing and then immediate irrigation). The major reason identified was that due to non-availability of DSR machine on time, dry sowing is the preferred method which offers more flexibility in sowing time as compared to *vatttar* sowing (sowing in pre irrigated fields) where optimum moisture may not coincide with the machine availability. Sowing was completed in the month of May by almost 100% farmers as against recommended practice of 1-15 June. Pre-emergence herbicide application of pendimethalin was adopted by most of the farmers (96%) who are doing DSR for the last many years, however timing of herbicide application differs between farmers. Very few (18%) farmers are applying pre-emergence herbicide after irrigation as against 82% farmers who first apply pre-emergence herbicide followed by irrigation. The dose of pre-emergence herbicide, *viz.* pendimethalin varies from 1-1.5 litre/acre. Seed rate of DSR mostly adopted by farmers is 15- 20 kg/ha. Germination was satisfactory in almost at all the farmers (98%) field. The major weeds observed in the fields were *Echinochloa colona*, *Leptochloa chinensis, Dactylectinium aegyptium, Cyperus rotandus*. 2-3 weed flushes were reported by the farmer during the *Kharif* 2022 season which may be due to uneven rains. The frequency of irrigation varies between 4-7 days in between successive irrigations in DSR as compared to almost every day irrigation application in puddled transplanted rice during initial 30 days. However, duration of irrigation application was 4-5 hours in case of DSR as compared to 2-3 hours in case of puddled transplanted rice. The incidence of foot rot/bakane was reported less in DSR as compared to puddled transplanted rice. Farmers reported weed problem as the major constraint in adoption of DSR.

Effectof different pre- and post-emergence herbicides on weed dynamics and productivity of direct-seeded rice

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A field investigation entitled "Management of *Alternanthera spp.* in rice *(Oryza sativa)* through different Pre- and Post-emergence herbicides" was conducted during the *Kharif* season of 2019 at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was laid out in randomized block design (RBD) with three replications and ten treatments, *viz.* pretilachlor(Rifit) 750 g/ha, bispyribac sodium (Nominee Gold)25 g/ha,fenoxaprop-p-ethyl (Whipsuper) 56.25 g/ha, cyhalofop-butyl (Clincher) 80 g/ha, penoxsulam+ cyhalofop butyl (Vivaya) 135 g/ha, penoxsulam (Duton)22.5 g/ha, metsulfuron methyl (Algrip) 4 g/ha,2,4-D ethyl Ester (Aura) 750 g/ha, weed free (Hand weeding) at 20, 40 and 60 days after sowing and weedy check. Rice variety '*Rajeshwari*' was taken during the investigation.The results of experiment revealed that application of penoxsulam+cyhalofop-butyl (Vivaya)135 g/ha, penoxsulam (Duton) 22.5 g/ha and bispyribac sodium (Nominee Gold) 25 g/ha, 2,4-D ethyl ester (Aura)750 g/ha, metsulfuron methyl (Algrip)4 g/ha increased the grain yield of rice over the weedy check. Among chemical weed control treatments, at 30 days after sowing, the weed free treatment recorded very less weed density. At 30 and 60 days after sowing among the chemical treatment the lowest weed density was observed under the application of penoxsulam + cyhalofop-butyl (Vivaya)135 g/ha and the highest weed density was recorded under the application of cyhalofop-butyl (Clincher)80 g/ha and fenoxaprop-p-ethyl (Whipsuper) 56.25 g/ha.While at harvest, among the herbicide treatments, the lowest weed density was recorded under penoxsulam + cyhalofop-butyl (Vivaya)135 g/ha (34.19/m^2). The highest weed density of total weeds was found in the plots treated with cyhalofop-butyl (Clincher)80 g/ha (82.66/m^2). The maximum weed control efficiency was computed under penoxsulam + cyhalofop-butyl (Vivaya) 135 g/ha (68.98%) followed by penoxsulam (Duton) 22 g/ha bispyribac sodium (Nominee Gold) 25 g /ha and 2,4-D ethyl ester (Aura) 750 g/ha. While, the lowest weed control efficiency(62.91%) was recorded under cyhalofop-butyl (Clincher) 80 g/ha (29.16%). The most dominant weed was *Alternanthera sessilis* in the experimental site based on the summed dominance ratio value.The maximum net retun (₹ 71409/ha) was attained under penoxsulam + cyhalofop-butyl (Vivaya) 135 g/ followed by pretilachlor 750 g/ha, bispyribac sodium (Nominee Gold) 25 g/ha and penoxsulam 22.5 g/ha. The minimum net return was obtained under weedy check treatment, which accounts for a net loss of ₹ 56,419/ha as compared to penoxsulam + cyhalofop-butyl (Vivaya)135 g/ha. The highest B:C ratio was recorded under penoxsulam (Duton) 22.5 g/ha followed by bispyribac sodium (Nominee Gold) 25 g/ha and penoxsulam + cyhalofop-butyl (Vivaya) 135 g/ha and metsulfuron methyl (Algrip) 4 g/ha. The minimum B:C ratio was noted under the weedy check treatment.Penoxsulam + cyhalofop-butyl (Vivaya) 135 g/ha was found as the best treatment.

Integrated weed management and crop establishment methods influenced the weed dynamics, yield attributes and yield of wet direct seeded rice in Eastern Uttar Pradesh

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Rice is very important crop for food sufficiency, trade, and rituals in Eastern Uttar Pradesh. Direct wet seeding offers the advantage over transplanted rice in terms of faster and easier planting, reduced labour and less drudgery, 7-10 days' earlier crop maturity, more efficient water use and higher tolerance to water deficit, less methane emission, and often higher profit in areas with assured water supply. This method of seeding in the past has received relatively less attention than transplanting. Sowing of sprouted rice seed or wet-seeded rice in puddled soil though becoming increasingly important as a method of crop establishment under lowland rice is beset with weed problems, particularly grassy and aquatic weeds besides other management practices. Weeds emerge at about the same time the rice seeds germinate, and therefore the yield losses caused by weeds will become greater with the trend towards wet seeding. Effective weed control is one of the key issue and major requirements to ensure a successful wet-seeded rice crop. Furthermore, varieties must be improved for early seeding vigour, weed competitiveness, submergence tolerance to survive untimely rainfall during stand establishment and drought tolerance to survive dry conditions during germination and later growth stages, and for lodging resistance at maturity. Therefore, field experiment was conducted during rainy season 2021 to evaluate the crop establishment methods and integrated weed management on weed dynamics, and yield of wet direct seeded rice (DSR) at the agriculture research farm of the Institute for Agricultural Sciences, BHU, Varanasi, India. RBD design was adopted with six treatments consist of S1: manual broadcasting of seeds; S2: Drum seeding + post-emergence herbicide; S3: Broadcasting + post-emergence herbicide; S4: Drum seeding + mechanical weeding; S5: Drum seeding + post-emergence + mechanical weeding; S6: Drum seeding + post-emergence herbicide + mechanical weeding + 4 split N application with three replications. The Variety '*HUR-3022*' was used for the investigation. In sandy loam soils of Varanasi, drum seeding + postemergence herbicide + mechanical weeding + 4 split N application resulted the highest grain yield (4.88 t/ha) followed by drum seeding + post-emergence herbicide + mechanical weeding (4.61 t/ha). Initial weed competition was less due to submergence of water by early monsoon and at later stages weed was managed by post-emergence herbicide and mechanical weeding with split doses of nitrogen as per the weeding resulted higher yield. Highest weed population (124.67 number/m^2) and weed dry weight (79.08 gm/m^2) recorded under S1 braodcasting + manual weeding. Whereas, drum seeding + postemergence herbicide + mechanical weeding + 4 split N application noted lowest weed population and weed dry weight (27.2 gm/m^2) at active tillering and panicle initiation stages.

Spray drift effect of imidazolinone herbicide on puddled transplanted non-tolerant rice cultivar

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The recent development in herbicide tolerant (imidazolinone) technology improved weed control in rice. In India, recently basmati varieties are released containing mutated acetolactate synthase gene that exhibiting tolerance to rice against imidazolinone based herbicides. However, spray drift effect of imidazolinone based herbicides still unknown on non-tolerant cultivar of rice. Therefore, a field experiment was conducted with the objectives to assess the effect of different amounts and times of spray drift on non-tolerant cultivar of rice under puddled transplanted conditions at CCS Haryana Agricultural University Regional Research Station, Uchani, Karnal during *Kharif* 2020 and 2021. The treatments were application of imazethapyr at the rate of 6.25% and 12.5% of 1-X dose (100 g/ha), pre-mix combination of imazethapyr + imazamox at the rate of 6.25% and 12.5% of 1-X dose (70 g/ha) with different time of drift *i.e.* 0, 10, 20 and 30 days after transplanting (DAT) along with control (non-treated check). All the treatments were replicated thrice in randomized block design. The herbicides were applied with knapsack sprayer fitted with flat-fan nozzle using a spray volume of 500 L/ha. Imazethapyr showed no phyto-toxicity on rice crop as reflected in grain yield (7270-7300 kg/ha) at 0 DAT and its toxicity increased with delayed stage of the crop with maximum at 30 DAT (5360-6080 kg/ha). Whereas, imazethapyr+ imazamox [ready-mix (RM)] more phyto-toxicity at 0 DAT (5640-6060 kg/ha) and its toxicity decreased with advancement in crop stage, with no phyto-toxicity at 30 DAT. The phyto-toxicity of both herbicides increased with increase in its concentration from 6.25% to 12.5%. Imazethapyr 6.25-12.5% at zero DAT and imazethapyr+ imazamox (RM) 6.25-12.5% at 30 DAT provided grain yield similar to untreated check. Similarly, during *Kharif* 2021 imazethapyr phyto-toxicity on rice crop increased from 0 DAT resulted in lower grain yield (5.87-6.15 t/ha) to 30 DAT (5.31-5.17 t/ha) and effect was more pronounced with higher dose of 12.5% than with 6.25% on conventional non-tolerant rice variety (HKR 47). Whereas, imazethapyr+ imazamox (RM) more phyto-toxicity at 0 DAT (5.83-6.10 t/ha) and its toxicity decreased with advancement in crop stage. Further, grain yield for 10, 20 and 30 DAT was found statistically at par with control (6.32 t/ha) except at 0 DAT with 12.5%. The phyto-toxicity of both herbicides increased with increase in its concentration from 6.25% to 12.5%. Hence, spray drift hazard of imidazolinone herbicide on non-tolerant rice cultivars could reduce its potential rice productivity. However, the drift problem can be reduced by proper scheduling of transplanting of puddled transplanted rice and timely application (post-emergence) of imidazolinone herbicides in herbicide tolerant rice.

Weed dynamics of direct-seeded rice as influenced by herbicidal mixtures under different agro-ecosystems

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Rice (*Oryza sativa* L.) is one of the world's most important food crops. Direct-seeded rice (DSR) is an emerging production technology in India due to lesser water, labour, and capital input requirements initially. But DSR has the problem of severe weed infestation. The success of DSR depends largely on weed control, especially with chemical methods, as mechanical weed control is labour intensive and not cost-effective. Various herbicides have been used for controlling weeds in DSR. Still, the efficiency of chemical methods based on a single herbicide treatment may be unsatisfactory because of their narrow weed control spectrum. Therefore, applying several herbicides in combination or sequence can be more useful. The field experiment was conducted in 2019 during the *Kharif* season at the Research Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, M.P. The experiment was laid out in split-plot design with three replications, comprising two agro-ecosystems (rainfed and irrigated) in main plots and eight weed control treatments: bispyribac-sodium 25 g/ha, fenoxaprop-p-ethyl 60 g/ha, fenoxaprop-p-ethyl + penoxsulam 60 + 26.7 g/ha, cyhalofop + penoxsulam 135 + 26.7 g/ha, bispyribac-sodium + (metsulfuron-methyl + chlorimuron ethyl) 25+4 g/ha, triafamone + ethoxysulfuron 40+20 g/ha as post-emergence (PoE) herbicides, hand weeding twice at 20 and 40 days after seeding (DAS) and weedy check) in subplots. A medium-duration rice variety '*MTU1010'* was sown in the second week of July 2019 at a row spacing of 20 cm. The dominant weed flora in the experimental field was: *Echinochloa colona, Alternanthera sessilis, Cyperus rotundus* and *Cynodon dactylon*. In the experimental field, *E. colona* (30 and 28.6%) was the most predominant weed, closely followed by *A. sessilis* (26 and 25%) under rainfed and irrigated agroecosystems. Bispyribac-sodium 25 g/ha PoE effectively controlled grasses, sedges and broad-leaved weeds with 89.5% weedcontrol efficiency (WCE) at 90 DAS. Growth parameters of rice (*viz*. plant height, number of tillers/m^2) and yield attributes (*viz*. number of effective tillers/m^2, number of grains/panicle) were higher with bispyribac sodium 25 g/ha PoE in comparison to all other herbicidal treatments. The grain and straw yield of rice varied significantly due to different weed control treatments. Significantly maximum grain and straw yield was obtained with hand weeding twice at 20 and 40 DAS over the rest of the treatments. Among the herbicidal treatments, bispyribac-sodium 25 g/ha PoE at 20 DAS recorded maximum grain (1.85 t/ha) and straw yield (2.96 t/ha) under irrigated conditions.

Non-chemical weed management in wet seeded and transplanted aromatic rice

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The aromatic rice of Assam is a unique class under *sali* (*kharif)* rice traditionally known as '*Joha*'. The *Joha* rice cultivars are known for its unique aroma, superfine kernel, good cooking qualities and excellent palatability. This class of rice has high demand in domestic market. There are different cultivars of *Joha, viz.*, *Kola Joha*, *Kon Joha*, *Keteki Joha*, *Ronga Joha*, *Badshabhog etc*. Among all these, *Kola Joha*, *Badshabhog* and *Keteki Joha* have very strong aroma. It has been observed that in direct-seeded rice (DSR), weeds are the main biological constraint of successful rice production. Yield losses due to weeds in low land rice fields ranges from 20-60% and 30-80% in transplanted and direct-seeded rice respectively. In conventional agriculture too, use of herbicides alone does not provide sustainable weed control. Weed management in organic production systems involves the use of many techniques and strategies to achieve economically acceptable weed control and crop yield. Organic weed control encourages weed suppression by promoting soil health through a combination of crop rotation, intercropping, bio-fertilizer and compost. In view of this, a field experiment was conducted during *sali* season of 2019 in organic block of Instructional-cum-Research farm of the Assam Agricultural University, Jorhat to study the effect of non-chemical weed management practices on weed, crop growth, yield attributes and yield of aromatic rice (*cv Kola Joha)* established by wet-seeding and transplanting. The experiment was laid out in split-plot design with main plots of two rice establishment methods, *i.e.* direct wet-seeded (WSR), puddled transplanting and sub plots of five organic weed management practices, *viz.* weedy check, hand weeding twice at 20 and 40 days after transplanting (DAT)/seeding (DAS), weeding with rotary weeder twice at 20 and 40 DAT/DAS, weeding with cono weeder twice at 20 and 40 DAT/DAS and intercropping of *dhaincha* and its incorporation at 40 DAT/DAS. The puddled transplanting method of rice establishment resulted significantly higher rice grain yield (1.82 t/ha), decreased weed density and biomass compared to the direct wet-seeding method. The hand weeding twice at 20 and 40 DAT/DAS produced the highest grain yield (2.19 t/ha), maximum weed control efficiency and weed control index. The next best was the intercropping of *dhaincha* and incorporation at 40 DAT/ DAS (1.69 t/ha), which recorded the highest B:C ratio (2.61) also under the puddled transplanting system of rice establishment.

Phytotoxic effect and economics of different herbicides on rice seedlings

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A field experiment was conducted at Regional Research Station, Anand Agricultural University, Anand during *Kharif* 2019. The experiment was laid out in randomized block design replicate thrice which consist 14 treatments, *viz.*, T_1 : pendimethalin 750 g/ha pre-plant incorporation (PPI), T_2 :pendimethalin 750 g/ha pre-emergence application (PE), T_3 : pendimethalin 750 g/ha PPI followed by (*fb*) bispyribac- sodium 20 g/ha post-emergence application (PoE), T_4 : pendimethalin 750 g/ha PE *fb* bispyribac- sodium 20 g/ha PoE, T_5 : pretilachlor 500 g/ha PE, T_6 : anilofos 300 g/ha PE, T_7 : oxadiargyl 90 g/ha PE, T_8: ethoxysulfuron 15 g/ha PoE, T_9 : bispyribac-sodium 20 g/ha PoE, T_{10} : metsulfuron methyl +chlorimuron ethyl 4 g/ha PoE, T_{11} : penoxsulam 20 g/ha PoE, T_{12} : rabbing of farm waste 10 t/ha, T_{13} : hand weeding at 15 DAS and T_{14} : weedy check. Significantly higher number of germinated seedlings, number of seedlings, transplantable seedlings, fresh weight and dry weight of rice seedlings were observed under hand weeding at 15 days after seeding (DAS). Penoxsulam 20 g/ha PoE recorded highest height, root and shoot length of rice seedlings. Among the different treatments hand weeding at 15 DAS recorded lowest weed count, total weed fresh weight, total weed biomass and highest weed control efficiency. Among the different herbicides lowest weed count (no./m^2) of *Echinochloa crus galli* (1.00/m^2), *Echinochloa colona* (1.18/m^2), *Digitaria sanguinalis* (1.47/m^2), *Dactyloctenium aegyptium* (1.00/m^2), *Ecilpta alba* (1.00/m^2), *Phyllanthus niruri* (1.00/m^2) and *Cyperus rotundus* (1.79/m^2) at 25 DAS were observed with penoxsulam 20 g/ha PoE followed by metsulfuron methyl + chlorimuron ethyl 4 g/ha PoE. Lower total fresh weight, total weed dry weight and maximum weed control efficiency at 25 DAS were achieved with hand weeding at 15 DAS. Among the herbicidal treatments minimum total fresh weight (6.66 g/m^2), total weed biomass (3.61/m^2) and maximum weed control efficiency (90.61%) were achieved with penoxsulam 20 g/ha PoE followed by metsulfuron methyl + chlorimuron ethyl 4 g/ha PoE. Pendimethalin 750 g/ha PPI, pendimethalin 750 g/ha PPI *fb* bispyribac-sodium 20 g/ha PoE, pretilachlor 500 g/ha and oxadiargyl 90 g/ha PE caused chlorosis injury on seedlings which recorded at 7,14 and 21 days after herbicides application. In case of pendimethalin 750 g/ha PPI and pendimethalin 750 g/ha PPI *fb* bispyribac-sodium 20 g/ha PoE there was severe cholorosis was observed. While, in case of pretilachlor 500 g/ha and oxadiargyl 90 g/ha, slightly injury was observed at 7 and 14 days after herbicide application, later on it was recovered. Other treatments were found safer without any phytotoxic effect on growth of rice seedlings. Maximum gross realization of (¹ 195300/ha) was recorded under hand weeding at 15 DAS. Maximum net realization (¹ 142419/ha) and highest BCR of (4.77) was achieved with penoxsulam 20 g/ha PoE followed by metsulfuron-methyl + chlorimuron-ethyl 4 g/ha PoE.

Weeds: a silent threat under different rice establishment methods

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A field trial was laid at the College Farm, Navsari Agricultural University, Navsari (Gujarat) throughout summer seasons of 2019-20 and 2020-21, in split-plot design and replicated four time. Three crop establishment methods were allocated to main plots, *viz.* S_1- direct-seeded sice, S_2- conventional transplanted rice, S_3- sprouted seed (line sowing) while five weed management practices in sub-plots inside each main plot were:, *viz.* W_1- weedy check (control), W_2- hand weeding (HW) twice at 20-25 and 40-45 days after seeding (DAS)/days after transplanting (DAT)T, W_3- pretilachlor 1000 g/ha pre-emergence application (PE) followed by (*fb*) bispyribac-sodium 25 g/ha at 30 DAS/DAT, W_4- pyrazosulfuron-ethyl 15 g/ha PE *fb* bispyribac-sodium 25 g/ha PoE at 30 DAS/ DAT and W_5- pretilachlor 1000 g/ha PE *fb* chlorimuron-ethyl + metsulfuron-methyl 4 g/ha at PoE 30 DAS/DAT. Rice cv. '*NAUR-1'* was used. Among all the rice establishment methods, the highest weed control efficiency was recorded under conventional transplanted rice (S_2) and lowest under direct-seeded rice (S_1) at 40 DAS/DAT as well as at harvest.At 40 DAS/DAT, the mean highest weed control efficiency was observed in W_3: pretilachlor 1000 g/ha PE *fb* bispyribac-sodium 25 g/ha PoE at 30 DAT/DAS (67.1%) followed by W_5: pretilachlor 1000 g/ haPE *fb* chlorimuron-ethyl + metsulfuron-methyl 4 g/ha PoE at 30 DAS/DAT (65.8%) and W_4: pyrazosulfuron-ethyl 15 g/ha PE *fb* bispyribac-sodium 25 g/ha at 30 DAS/DAT (65.4%). Further at harvest, HW twice at 20-25 and 40-45 DAS/DAT (W_2) recorded highest weed control efficiency (W_2: 83.6%). On pooled basis of two years, application of pretilachlor 1000 g/haPE *fb* chlorimuron-ethyl + metsulfuron-methyl 4 g/ha PoE at 30 DAS/DAT (W_5) recorded the lowest weed index (2.36%) and was followed by pretilachlor 1000 g/haPE *fb* bispyribac-sodium 25 g/ha PoE at 30 DAT/DAS (W_3). conventional transplanted rice (S_2) produced significantly the maximum grain yield in year 1, year 2 and in pooled, respectively as compared to rest of establishment methods. Further, direct-seeded rice (S_1) recorded minimum grain yield which was observed at par with sprouted seeds line sowing (S_3) during both the season as well as in pooled analysis. HW twice at 20-25 and 40-45 DAS/DAT (W_2) recorded significantly higher grain yield followed by pretilachlor 1000 g/haPE *fb* chlorimuron-ethyl + metsulfuron-methyl 4 g/ha PoE at 30 DAS/DAT (W_5). Significantly higher grain yield was recorded in conventional transplanting with HW twice at 20-25 and 40-45 DAS/DAT during season 1, season 2 and pooled analysis, respectively.

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Influence of critical period of crop-weed competition in aerobic rice

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A field experiment was conducted at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during *Kharif* season of 2014. The soil of Navsari campus has been placed under the great group *Ustochrepts* with Jalalpur series. The experiment was laid out in Randomized Block Design with three replications and ten treatments, *viz*., T_1 -weed free up to 15 days after seeding (DAS), T_2 -weed free up to 30 DAS, T_3 -weed free up to 45 DAS, T_4 -weed free up to 60 DAS, T_5 -weed free up to harvest, T_6 -weedy up to 15 DAS, T_7 - weedy up to 30 DAS, T_8 -weedy up to 45 DAS, T_9 -weedy up to 60 DAS and T_{10} -weedy up to harvest. The experimental field was infested by number of weed species comprising of monocot weeds, *viz*. *Echinochloa crus galli* (L.), *Echinochloa coluna* (L.), *Cynodon dactylon* (L.), *Dactyloctenium agegyptium*, *Bracharia* spp., *Cenchrus biflorus*, *Eichhornia crassipes*, dicot weeds, *viz*., *Physalis minima*, *Alternanthera sessilis*, *Euphorbia hirta*, *Digera arvensis* (L.), *Cardiospermum halicacabum*, and sedges *Cyperus rotundus* (L.) predominantly during the course of experimentation. Weed density recorded at 15, 30, 45, 60 and at harvest revealed that various treatments considerably reduced the weed density at all the stages of crop growth. All the treatments significantly reduced the weed density as compared to treatment T_{10} (weedy up to harvest). While, treatment T_5 (weed free up to harvest) registered the lowest monocots, dicots, sedges and total weeds density at all stages of crop growth (at 15, 30, 45, 60 DAS and at harvest). Weed competition index, which is the indicator of losses in grain yield due to presence of weeds. Treatments T_5 (weed free up to harvest) was considered as base for calculating weed competition index. Therefore, treatment T_5 recorded the lowest weed competition index (0.00%) followed by T_4 (8.88%), T_6 (11.10%) and T_3 (15.13%). Significantly higher amount of nutrient uptake by rice crop was under the treatment of T_5 (weed free up to harvest) closely followed by T_4 (weed free up 60 DAS), T_6 (weedy up to 15 DAS) and T_3 (weed free up to 45 DAS). In case of weeds the higher nutrient uptake by weeds was recorded under the treatment T_{10} (weedy up to harvest). The highest grain yield was under treatmentT_5 *i.e.* weed free up to harvest being statistically at par with the treatment T_4 and T_6. For higher yieldand less weed infestation of *Kharif* aerobic rice the crop weed free during the period of 45 to 60 days after sowing.

Weed growth and productivity of rainfed upland rice with integration of herbicides and straw mulching

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Direct-seeded rice (DSR) has been introduced as an affirmative substitute of transplanted rice. But lower productivity is marked in DSR mainly due to weeds infestation. Manual weeding involves greater physical energy which makes it cost intensive and hard to apply. In these situations, herbicides play a significant role in controlling the weeds. Most of the herbicides are applied in large quantities and sole application is not at all advisable from sustainable point of view. Thus, weed control through herbicide(s) coupled with any physical or cultural practices would be beneficial in integrated plant management systems, while minimizing the impact of agrochemicals; which is an important concern in current agricultural activities. An experiment was conducted to study the effect of herbicide and straw mulch on weed growth and productivity of directed-seeded rice, during *Kharif* season, 2019 at Agricultural Research Station, Binjhagiri, Chhatabar, Bhubaneswar. The experiment was replicated thrice in the randomized complete block design (RCBD) with twelve treatments. The twelve treatments included: pre-emergence application (PE) of pendimethalin at 750 g/ha at 1 day after seeding (DAS), oxadiargyl at 70 g/ha PEat 1 DAS, rice straw mulch at 4 t/ha at 3 DAS, rice straw mulch at 6 t/ha at 3 DAS, pendimethalin PE folloed by (*fb*) rice straw mulch at 4 t/ha, pendimethalin PE *fb* rice straw mulch at 6 t/ha, oxadiargyl PE *fb* rice straw mulch at 4 t/ha, oxadiargyl PE *fb* rice straw mulch at 6 t/ha, pendimethalin PE *fb* hand weeding at 35 DAS, oxadiargyl PE *fb* hand weeding at 35 DAS, weed free and weedy check. Rice *cv* '*Mandakini*' seeds of 75 kg/ha were sown with row to row spacing of 20 cm at a depth of 3 cm in north-south direction. The air-dried rice straw grown in the previous year was used as mulch. The rice straw was spread in the inter-row space onto the soil surface at varying rate as per treatment. Observations of the parameters were recorded at 60 DAS and at the time of harvest by following standard procedure. The predominant weeds in the experimental area were: *Poa annua*, *Digitaria sanguinalis*, *Echinochloa colona*, *Cyperus iria*, *Ludwigia parviflora*, *Melochia corchorifolia* and *Alternanthera philoxeroides*. The application of oxadiargyl PE *fb* rice straw mulch at 6 t/ha registered significantly the lowest weed density and biomass of total weeds, which was statistically at par with oxadiargyl PE *fb* hand weeding treatment. The significantly highest productivity (3.05 t/ha) was recorded with weed free, which was found to record statistically similar yield as with oxadiargyl PE *fb* rice straw mulch at 6 t/ha (2.99 t/ha) and oxadiargyl PE *fb* rice hand weeding (2.90 t/ha). These treatments could be recommended for managing complex weed flora and obtaining higher yield of rice during *Kharif* season.

Efficacy of triafamone for broad spectrum weed management in direct-seeded rice

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Rice (*Oryza sativa* L.) is a principal source of food for more than half of the world population, especially in South and Southeast Asia, where it is mainly grown by manual transplanting of seedlings but recently the direct seeded rice systems is preferred to traditional manual transplanting of seedlings, in many Asian countries. Direct seeding of rice (DSR) may involve sowing pre-germinated seed onto a puddled soil surface (wet seeding) or into shallow standing water (water seeding), or dry seed into a prepared dry seedbed (dry seeding). In the last two decades DSR is gaining popularity because of rising production costs, high labor costs and less availability of water but weeds management is considered one of the major limitation in these systems. The flushes of weeds, are mainly controlled by using specific herbicides or manually. However, manual weeding is becoming less common because of the non-availability of labor at critical times and increased labor costs. So, herbicides are replacing manual weeding as they are easy to use and labour saving. Thus, a field experiment was conducted during *Kharif* season 2019 at G.B.Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. During the total growing period from June to October 2019, the total rainfall was received was 1119.4 mm and the relative humidity ranged from 59.2 to 83.4%. The average maximum and minimum temperatures were 33.4^{0}C and 23.9^{0}C. The experiment comprised of total nine treatments, *viz.* control (untreated- T_1), triafamone at 30 (T_2), 40 (T_3), 50 (T_4) g/ha, pyrazosulfuron ethyl 15 g/ha (T_5), cyhalofop butyl 80 g/ha (T_6), farmer's practice hand weeding twice at 20 and 40 days after sowing (DAS), T_7) and weed free (T_8) in a randomized block design with four replications using rice variety *Pant Dhan-18*. All the experimental hericides were applied as post-emergence application (PoE) at 2-3 leaf stage of weeds using knapsack sprayer fitted with flat fan nozzle. It was observed that triafamone 40 to 50 g/ha PoE is effective for management of weeds like *Echinochloa colona, Echinochloa crusgalli, Caesulia axillaris, Alternanthera sessilis, Ammenia baccifera* and *Cyperus rotundus* and also recorded highest yield of direct-seeded rice. There was no phytotoxicity effect on direct-seeded rice and there was no significant residual toxicity effect of weed control treatments on the succeeding crop *i.e.* wheat. Thus, it can be concluded that triafamone 200 SC at 40 to 50 g/ha PoE may be the ideal in direct-seeded rice to control most of the weeds and obtaining higher rice yield.

Efficacy of acetolactate synthase (ALS) and acetyl-CoA carboxylase (ACCase) inhibitor herbicides on weed growth and yield in direct-seeded rice

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The direct-seeded rice (DSR) has become a practical alternative for growing rice in many parts of the world and DSR's long-term viability is threatened by the diversity of weed flora and the advent of novel weed biotypes. For DSR to be successful, effective weed management is crucial. Different herbicide combinations contain one or more inhibitor mechanisms that work together to suppress a wide range of weeds while reducing the amount of herbicide released into the environment and the expense of treatment. Herbicides that are ALS inhibitors prevent the production of valine, leucine, and isoleucine. Whereas the acetyl-CoA carboxylase (ACCase), a crucial enzyme for the development of membranes that catalyses the initial stage in the production of fatty acids, is prevented by ACCase inhibitor herbicides. The experiment was conducted in 2021 during the *Kharif* seasons at the Agricultural Research Farm, Banaras Hindu University, Varanasi. The trial was laid out in Randomized Block Design (RCBD) with 9 weed management treatments. In our study, the ALS-inhibiting herbicides tested were bispyribac sodium 20% + pyrazosulfuron 15% WDG, bispyribac sodium, pyrazosulfuron, triafamone 20% + ethoxysulfuron 10% WG, whereas penoxsulam 1.02%+ cyhalofop-butyl 5.1% OD inhibited the ACCase. Paddy seeds (MTU-7029) are spread directly on dry soil by local furrow maker "*Kudali*" at a seed rate of 35 kg/ha with an inter-row spacing of 20 cm. The major weeds flora found during the entire duration of rice crop were: *Cynodon dactylon, Echinochloa colona, Leptochloa chinensis, Paspalum distichum, Cyperus rotundus, Fimbristylis miliacea, Caesulia axillaris, Eclibta alba, Trianthema portulacastrum, Lindernia procumbens, Physalis minima, Spilanthes acmella, Parthenium hysterophorus*and *Phyllanthus niruri*. Combination of ALS inhibitor herbicide, *viz.* bispyribac Na 20% + pyrazosulfuron 15%WDG + silicon-based non-ionic surfactant 52.50 g/ha wasfound to be most efficient in reducing weeds density and biomass, with higher weed controlling efficiency (WCE). Better WCE observed in bispyribac Na 20% + pyrazosulfuron 15% WDG + silicon based non-ionic surfactant52.50 g/ha resulted in the highest rice grain and straw yields, followed by bispyribac Na 20% + pyrazosulfuron 15% WDG + silicon based non-ionic surfactant 61.25 g/ha and triafamone 20% + ethoxysulfuron 10% WG66.5 g/ha. Hand weeding twice at 20 and 40 DAS was used for comparing herbicidal treatments recorded a considerably lower weed density, weed biomass, and a greater WCE compared to all the tested herbicide-based weed management treatments.

TECHNICAL SESSION 8

Herbicide resistance in weeds, herbicide tolerant crops and Weed utilization

Herbicide options for the control of multiple herbicide resistant *P. minor* in wheat at farmer's fields in Haryana

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Rice- wheat is the important cropping system of Tohana area of Haryana from where first case of isoproturon resistance *P. minor* was reported from villages Lalaoda and Nangla. During 1997, three alternate herbicides, *viz.* clodinafop, sulfosulfuron and fenoxaprop, recommended to control this isoproturon resistant population, worked very well up to 2005 but from 2006 to 2010, again symptoms of cross resistance appeared in all these isoproturon resistant *P. minor* occurring villages of Haryana which was confirmed by scientists of CCS HAU Hisar and DWBR, Karnal in many pots as well as field studies. Even this biotype of *P. minor* showed regeneration with use of recommended dose of meso+ iodosulfuron (RM) 14.4 g/ha and pinoxaden 50g/ha after its use for 4-5 years. Now from field studies it was confirmed that *P. minor* has developed multiple herbicide resistance in all areas of rice-wheat cropping sequence in Haryana. Pre-emergence herbicides pyroxasulfon and pendimethalin although provides very effective control of *P. minor* but soil moisture is a big constraint for having good efficacy in fields where rice is harvested by combine harvesters and paddy straw if present impedes the flow of herbicide to reach soil surface or if wheat is sown after burning paddy straw, ash also cause hinderance to herbicide to reach soil surface. Keeping it in view, two experiments were conducted at field of S. Devender Singh Gill of Village Nangla using pre-emergence application (PE) of pyroxasulfuron + pendimethalin (127.5 +1500 g/ha), with three volumes of water (375, 500, 750 L/ha) *fb* early post-emergence application (EPOST) of metribuzin 350 & 525g/ha just one day after first irrigation either alone or *fb* meso+ iodosulfuron (RM) 3.6% WDG 14.4 g/ha at 35 -40 DAS. In another experiment, a field with history of multiple resistance of 0.8 ha size where rice straw was burnt before wheat disking by ZT seed drill, pyroxasulfuron + pendimethalin (127.5 +1500 g/ha) PE were applied using 750 L water/ha *fb* pinoxaden 5.1% EC at 50, 60 and70 g/ha alone or tank mixture with metribuzin 87.5 g/ha, meso+ iodosulfuron (RM) 3.6% WDG 14.4 g/ha, clodinafop + sulfosulfuron (120+25 g/ha) as farmers' practice in a plot size of 1000 m^2. As the water volumes increased from 350 to 750 litres/ha, *P. minor* percent control increased as recorded by its density at 20 DAS. EPOE use of metribuzin at both 350 and 525 g/ha helped to prevent the new emergence of *P. minor* and even stunted and controlled freshly germinated seedlings but higher dose (525 g/ha) caused 10% yellowing of wheat crop. Pyroxasulfuron + pendimethalin 127.5 +1500 g/ha PE using 750 L water/ha fb metribuzin 350g/ha EPOE *fb* meso+iodosulfuron (RM) at 14.4 g/ha applied at 40 DAS provided 87% control of *P. minor* with wheat grain yield of 4880 kg/ha. In second experiment, pyroxasulfuron + pendimethalin 127.5 +1500 g/ha PE using 750 L water/ha *fb* pinoxaden 70 g/ha at 40 DAS provided 92% control of *P. minor* with wheat grain yield of 5140 kg/ha *fb* pyroxasulfuron + pendimethalin 127.5 +1500 g/ha PE and pinoxaden+ clodinafop 50+87.5 g/ha with 85% *P. minor* control and wheat grain yield of 4800 kg/ha without toxicity to wheat. Thus, in wheat crop, multiple herbicide resistance in *P. minor* can be tackled by using pre- and post-emergence herbicides both.

Agronomic options for sustainable management of herbicide resistant weeds in climate change era

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Weed management is a prerequisite for realizing higher crop yield of better quality under the climate change era. In fact, globally herbicides are leading group of pesticide with a consumption share of 44% followed by fungicides (27%) and insecticides (22%) and the unavailability of labour and high wage rates are increasingly forcing the farmers to use herbicides for weed control besides that the herbicides are more most cost-economic. However, the repetitive usage of a few selective herbicides with same mode of action are also resulting in herbicide resistance in a few weed species. The estimates revealed that, till date there are 513 unique cases of herbicide resistant weeds with 267 species (154 dicots and 113 monocots) and it has already been reported in 96 crops and 72 countries across the world. ALS/AHAS, PS II and ACCase inhibitors group of herbicides contribute the major share for herbicide resistance in weeds. In India, resistance so far, is confined only to *Phalaris minor* and *Rumex dentatus* in wheat against ALS/AHAS and ACCase inhibitor group herbicides. Altered target site of action, enhanced metabolism, compartmentalization or sequestration are the three mechanisms to evolve herbicide resistance. Therefore, it is important to identify and adopt the possible eco-friendly agronomic options for successful management of herbicide resistance. The various agronomic tactics such as selection of certified seed, clean tillage, mulching, soil solarization, roughing operation, manual weeding, stale seed bed technique, close row to row spacing, crop residue management, crop rotation, use of appropriate herbicide (dose, time of application, rotation, herbicide mixtures, selection of short duration residual herbicide) and integrated weed management (IWM) are some of the possible options.

Herbicide resistance in weeds and their management- A Review

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Weeds have been a problem creator in the crop production practices since time immemorial. The weeds are known to cause around 37- 45% yield reduction in crops. Out of all the methods of control of weeds, the most prominently used one is the chemical control of weeds. The herbicide being an effective and quick option towards weed control have made farmers more stooped towards them. The unavailability of labours and their high wages also aid in the increased usage of herbicides. This increased use of herbicides has led to the development and evolution of herbicide resistant weeds and shift in weed flora and thus created an imbalance in the ecosystem. Herbicide resistance is "the inherited ability of a weed to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type" (WSSA). Herbicide resistance is a result of evolution of weeds, resulted from the selection pressure laid by the usage of similar herbicides or herbicides having same mode of actions. It is a global phenomenon, and the number of resistant weed biotypes is expanding at an alarming rate. Therefore, their management in crop production is as important as crop production itself. If herbicide resistance is confirmed or highly suspected, diverse approaches to managing herbicide resistance need to be incorporated into weed management strategies immediately for the species in question. This paper acknowledges the concept of herbicide resistance and its development, the mechanism of herbicide resistance development, its types, and also brings in light, the technological options for the management of herbicide resistant weeds. The management of herbicide resistance weeds does not rely on a single measure for the control of weeds but includes an array of techniques and tools to prevent the evolution and spread of these weeds. Thus, an appropriate combination of chemical, non-chemical biochemical and genetic methods would be greatly helpful in the management of herbicide resistance in weeds. Herbicide resistance is unavoidable event, however it can be delayed with the inculcation of scientific technologies and management practices.

Usefulness of avenue shrub, butterfly pea (*Clitoria ternatea)*

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The physiological processes in plants during stress and the adaptation of plants towards extreme environments may alter the metabolite profiles. The naturally occurring secondary metabolites in plants, including various elicitors, may overcome the stress conditions. The local geoclimate-, and external conditions such as water, soil aeration and soil fertilizer affect the composition ofbioactive compounds. Malaysia is rich in species diversity and hosts approximately12,500 species of flowering plants and 185,000 species of fauna, which are endemic to tropical forestry in the region. *Clitoria ternatea* is moderately resistant to abiotic stress regardless of its beneficial phytoconstituents that could be applied in the industrial sector. *Clitoria ternatea* is a tropical flower that is widely found growing in gardens and also in the wild. *Clitoria ternatea* is also known as utterfly pea and blue pea in various countries. *C. ternatea* is very easy to grow and maintain. Butterfly pea flower is a plant species that is in the Fabacaeae family. *C. Ternatea* classified as kingdom Plantae, phylum Tracheophyta, class of Magnoliopsida and a family of Fabaceae. Morphologically, *C. ternatea* is a herbaceous perennial legume and can vary with different growing conditions. The plant is a native to Zimbabwe, Ghana, Guinea, Malaysia and Indonesia. However *C. ternatea* has been introduced to tropical Australia, America and South Africa. Since *Clitoria ternatea* is widely spread over many countries, it is also known by many common names. For Malaysia it is 'bunga telang', while in Konkani it is 'shankha pushpa' and 'gokarna'blue- pea, cunha (Brazil), pokindong (Philippines), kordofan pea (Sudan), Kokkattan (Tamil), Aparajita (Bengali) and also Aparajit in Hindi. In Ayurveda medicine, *Clitoria ternatea* is considered as a nootropic herbs (Medhya- Rasayana) comprising herbs such as *Conscora decusata* (Gentianaceae), *Evolvulus alsinoides* (Convolvulaceae) and *Convolvulus pluricaulis* (Convolvulaceae). Ecologically, the butterfly pea flower commonly prefers full sunlight, however sometimes partially shaded is more favourable. Seeds can be germinated by soaking them in water overnight Germination occurs within 1-2 weeks while flowering occurs within 4 weeks. The propagation for *Clitoria ternatea* includes the stems which are fine twinning as it can grow to 3 m long. Other than that, the leaves are pinnate with 7 leaflets. Leaflets are nearly orbicular or ovate 3 cm wide (max) and 5cm long (max.). It has been reported that butterfly pea flower plays an important role in nervine medicine as well as improving brain system and boosting memory. In terms of *C. ternatea* as a medicinal plant, the whole part of the plant is beneficial for medical treatment. The juice extract from the flowers of *C. ternatea* has been reported to cure skin diseases and insect stings. The roots are used to treat inflammation, burning sensation, in ophthalmology, amentia, asthma, ascites and hemicranias. In addition, the stem, root and flower of *C. ternatea* are recommended for the treatment of animal sting, such as snakebite or scorpion in India. Moreover, there has been research suggesting that anthocyanin helps in protecting the cell, as an anti-ageing agent, protects cell damage and promoting healthy eyes. Therefore, in realizing the many benefits of *C. ternatea* to humans, it is very important to investigate the phytochemicals of the plant by varying several parameters for better quality. The production of phytoconstituents in *C.ternatea* can be controlled by changing the environmental condition.

Usefulness of rice weed barnyard grass (*Echinochloa* spp.)

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In the last few decades there has been an exponential growth in the field of herbal medicine. It is getting popularized in developing and developed countries owing to its natural origin and lesser side effects. Plants are a valuable source of a wide range of secondary metabolites, which are used as pharmaceuticals, agrochemicals, flavours, fragrances, colours, biopesticides and food additives. The preliminary phytochemical studies showed that *Echinochloa crus-galli* contained alkaloids, glycosides, carbohydrates, flavonoids, phytosterols/terpenes, proteins, and saponins. Nutritional analysis of plant grains showed that they contained protein 9.0-13.7%, fat 2.3-3.5%, carbohydrates 63.8-79.9%, fiber 5.2-29.9%, energy 310-364 k cal, Ca 8 mg/ 100g, Fe 2.9 mg/ 100 g, thiamin 0.41 mg/100g, riboflavin 0.28 mg/100g and niacin 4.5 mg/ 100g**.** The previous pharmacological studies revealed that the plant possessed antidiabetic, anticancer, antioxidant, antimicrobial hypolipidemic and anti-obesity effects. The current review will discuss the chemical constituents and pharmacological effects of *Echinochloa crus-galli*.Common names includes: English: barnyard grass, barnyard millet, cocksfoot grass, cockshin grass, India: Samak, Sanwak.It is an annual, culms erect to decumbent, 0.8-1.5 m tall, rather thick, branching at base; leaves flat, glabrous, elongate, 30-50 cm long, 1-2 cm broad, scabrous, slightly thickened at margin; ligules absent; sheaths smooth, lower ones often reddish; panicle 8-30 cm long, green or purple, exserted, somewhat nodding, densely branched, the branches to 5 cm long, erect or ascending, sessile; spikelets 3-4 mm long, densely arranged on branches, ovoid, awnless, but move often long-awned, pale green to dull purple, short-bristly along veins; racemes spreading, ascending or appressed, the lower somewhat distant, as much as 10 cm long, sometimes branched; glumes and lower. It can be traditional used as a Seed can be cooked whole or ground into a flour and used in porridges, macaroni, dumplings *etc*. The seed characterized by somewhat bitter flavor. It was used traditionally as preventative and tonic, for carbuncles, hemorrhage, sores, spleen trouble, cancer and wounds.Bioassay-guided fractionation of the seeds of *Echinochloa crus-galli* lead to isolation of two cytotoxic flavonoids. They showed cytotoxic effect when screening against four human cancer cell lines [MCF-7 (breast cells), HCT-116 (colon cells), HELA (cervical cells) and HEPG-2 (liver cells)] using the sulforhodamine B (SRB) colorimetric assay. Different extracts of the seeds of *Echinochloa crus-galli* showed a dose dependent inhibition in a range of 5– 50µg/ml. The ethanolic extract (95%) proved to be the most active extract against HELA cell line (IC50=12µg/ml). On the other hand, the hexane and chloroform fractions exhibited moderate activities against HEPG-2 (IC50=15.5µg/ml) and HCT-116 (IC50=17.1µg/ml) cell lines, respectively. Two flavonoids were isolated from the chloroform fraction, they were identified as 5,7-dihydroxy- 3',4',5'-trimethoxy flavone and quercetin. 5,7- dihydroxy-3',4',5'-trimethoxy flavones, they exhibited potent cytotoxic activities against HELA cell line (IC50=4.5µg/ml) and HEPG-2 cell line (IC50=4.5µg/ml), which were comparable to doxorubicin (IC50=4.3µg/ml). Quercetin showed moderate cytotoxic effects against MCF-7, HCT-116, HELA and HEPG-2 cell lines with IC50 values of 12.7, 20.4, 13.9 and 11.3µg/ml, respectively.

Anticarcinogenic properties of leguminous bund weed (*Tephrosia purpurea)*

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T. purpurea belongs to the family Fabaceae of the class Magnoliopsida and order Fabales. There are around 850 plant names of species rank for genus *Tephrosia* out of these 362 are accepted plant names. Twenty-four species of *Tephrosia* have been recorded in India. The Greek word "*Tephros*" meaning "ash-colored" implying to grayish tint present in leaves gave rise to generic name and the word "purpurea" suggests the presence of a purple colored flower. *T. purpurea* is named "sarwawranvishapaka" in Sanskrit due to its ability to treat all kind of wounds. In fact, all parts of the plant have been used by traditional healers to cure various wounds. Rice water containing *T. purpurea* roots has been used to treat old and dirty wounds. Due to its effec- tiveness in the treatment of liver and spleen, it is known as plihari or pli- hasathru, where plihari stands for spleen. Roots are helpful in treating spleenomegaly either by chewing directly or taking with butter. Root decoction is use- ful in the treatment of enlarged and obstruction of liver, spleen, and kidney and jaundice and hepatomegaly aretreated using the whole plant, it is due to these prop- erties that *Tephrosia* is a prominent ingredient of preparations like Yakrifti and Tephroli which are used in treating liver disorders. leaf extracts of *T. purpurea* have good cytotoxic activity against MCF-7 human breast cancer cell line. Gnanaraja and Prakash (2014) reported that methanolic extract of this plant showed great potential against *n,n* diethylnitrosamine - inducedhepatocellular carcinoma in Swiss albino. Aqueous and ethanolic extracts of roots of this plant showed potential anticancer activity against Ehrlich ascites carcinoma cells in Swiss albino mice. Ethanolic extract was able to reduce thiobarbituric acid reac- tive substances (TBARS) level and also enhances the antioxidants sta- tus in the circulation of 1,2-dimethylbenz-(a)-anthracenes-painted hamsters (Duraipandiyan & Ignacimuthu 2007). *Tephrosia purpurea* roots and leaves can be used mainly in the treatment of wounds, cough, asthama, flatulence, dys- pepsia, elephantiasis, impotency, and urinary disorders. Some indica- tions from ethnomedicines have been validated by pharmacological activities of the plant extracts and its isolated compounds. The ethnomedicinal data reveal that the roots and leaves are a potential source for the treatment of bilharzias (schistosomiasis), snake bite, impotency, and elephantiasis disorders. Unfortunately, the pharmaco- logical studies in these areas are still insufficient to substantiate these preventive effects. The available literature showed that flavonoids present in the plant are most likely responsible for the antiulcer activity, and â-sitosterol has been reported to play a protective role in certain types of cancer such as breast, colon, and prostate cancer, while antioxidants might be responsible for hepatoprotective and anticancer properties. It is crucial to elucidate in-depth molecular mechanisms, structure–activity relationships, and potential synergistic and antago- nistic effects of multicomponent extracts and bioactive constituents derived from *T. purpurea*. Further studies should also focus on its long-term and adverse toxic effects on target organs in correlation with the specific pharmacological activity.

Management of multiple herbicide resistance in *Phalaris minor* through pre- and post-emergence herbicides

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Wheat (*Triticum aestivum* L.) is India's second most important food grain crop after rice. India is the world's second-largest wheat producer after China. India contributes to about 14% of the world's wheat production. Worldwide, wheat was grown on an area of 224.5million hectares with a production of 792.4 million tonnes in the year 2020-21. India produces 108.75 million tonnes of wheat from a land area of 31.76 million hectares with average national productivity of 3424 kg/ha. There are a number of factors responsible for lower wheat productivity in India, but weeds are one of the most significant biotic factor. Weeds compete for nutrients, light, moisture and space with the main crop. Phalaris minor is the most problematic weed in wheat crops, especially in rice-wheat cropping systems. Haryana, an important grain-producing state, is seeing a significant decline in productivity and profitability as a result of P. *minor* infestation. After developing multiple herbicide resistance, the threat posed by *P. minor* has grown. The dwarf wheat's higher water and fertiliser (especially nitrogen) requirements as well as the low-temperature requirement for better tillering favoured the weed. Because of its extremely aggressive capacity, it develops alongside the germinating wheat crop, seeks water and significantly reduces crop yield. Keeping all this in view, field studies were performed at CCS Haryana Agricultural University, Hisar (India) during *Rabi* 2020-21 and 2021-22 for management of multiple herbicide resistance in *Phalaris minor* in wheat crop. At 90 DAS, application of pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha PRE fb POE mesosulfuron + iodosulfuron (RM) 14.4 g/ha (91.5 and 88.7%, respectively) resulted in higher weed control efficiency and it was closely followed by PRE flumioxazin + pendimethalin (TM) 125 + 1500 g/ha (91.1 and 88.2%, respectively) and pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha as PRE fb pinoxaden + metsulfuron (TM) 50 + 4 g/ha. Lowest weed index (3.4 and 2.6%, respectively) was reported with Pre-emergence application of pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha fb POE mesosulfuron + iodosulfuron (RM) 14.4 g/ha during both the years of study. Higher grain yield (5847-5369 kg/ha) of wheat was recorded with pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha (PRE) fb POE mesosulfuron + iodosulfuron (RM) 14.4 g/ha (60-69.5% higher than weedy check) and it was statistically at par with pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha was used as PRE fb POE pinoxaden + metsulfuron (TM) 50 + 4 g/ha (59.1-68.6% higher than weedy check) and pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha (PRE) clodinafop propargyl + metribuzin (RM) 174 g/ha (54.1-64.7% higher over weedy check) during both the years of study.

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Herbicide resistant weeds and their management

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Herbicides are most popular and effective for weed management due to their higher efficacy and time saving nature. But the continued use of herbicides created many problems like weed resistance, shift weed in shift flora and environment hazards. The main reasons of resistance are lack of rotation of the herbicide and use of herbicides with long residue period. Herbicide resistance is a worldwide phenomenon and number of resistant biotypes of weeds is increasing at an alarming rate. A population of one type of weed may be completely eliminated by a herbicide leaving a small number of individuals with the genetic ability to resist it. Herbicide-resistant individuals may naturally exist in weed populations at very low rates as a result of uncommon random genetic changes. The periodicity depends on the kind of weed and the method of action of the herbicide. Herbicide resistance is a vulnerable plant's developed ability, weed population to endure herbicide treatment and finish its life cycle when the herbicide is applied at usual rates in a farming environment. For some herbicides, such as the ALS inhibitors, the frequency of resistant individuals prior to herbicide application may be as high as 1 in 10,000 meaning that ALS inhibitors are prone to a rapid development of resistance. Worldwide, there were more than 249 herbicide resistant weedy biotypes in 47 countries. The likelihood of developing herbicide-resistant weeds is increased by some management techniques, such as using the same herbicides repeatedly. Monoculture typically encourages the usage of the same herbicide. Resistance is likely to develop in annual weed species as they generate enormous quantities of seeds (pigweed, lamb's-quarters\sand foxtail are good examples of these sorts of weeds). Herbicides should only be used when absolutely necessary, at the approved rate, in herbicide mixes containing two or more herbicide groups and alternately between herbicide groups. The rotating of herbicides controls the resistant weeds. Crops that are herbicide-tolerant offer the chance to manage current herbicide-resistant weed populations using a variety of herbicide modes of action. The new idea for managing herbicide-resistant weeds is to grow crops that can withstand herbicides. It has characteristics that enable them to resist certain herbicides, which in the past would have caused crop mortality in addition to the intended weeds.

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Herbicide resistance: Mechanism and probable solutions

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Herbicide resistance in weeds has presented various difficulties for weed scientists and is an ongoing and unavoidable process that is always evolving with time. Although herbicides are the most popular and successful weed control method, the development of multiple herbicide resistance in undesirable plant species puts many crops’ yield and profitability at risk. The two types of herbicide resistance mechanisms are those involving the herbicide target site (also known as target site resistance, or TSR), and those involving pathways unrelated to the target site (also known as non-target site resistance or NTSR). Through sequential selection and/or gene flow, weeds build up a variety of resistance mechanisms, and long-distance and worldwide movement of herbicide-resistant weeds has proven to be a severe problem. Metabolic resistance pathways may impart resistance to a variety of herbicides, even some whose active ingredients are still unknown. There are less and fewer effective herbicides available over time for some aggressive weeds because the rate of resistance development is advancing faster than the rate of new herbicide discovery. If the patterns of usage of the herbicide are not altered, a new site of action for the herbicide will not be able to address the root causes of resistance. As seen by the consistent and predictable advancement of resistance evolution in weed populations and species reported every year, and every herbicide identified in the past and in the future has the potential to select for resistance over time. For herbicide use to be sustainable, it is essential to maintain the diversity of weed management techniques and the efficacy of non-chemical management methods. Any weed management technique used to lessen the pressure of selection for resistance would slow the establishment of resistance. The monitoring of species mobility and the presence of resistance within species is a crucial part of integrated weed management, necessitating practical and precise diagnostic techniques. Emphasis should be given on integrated weed management techniques, optimising crop diversity, destructing the weed seed bank, avoiding the entry of new weed seeds, and spending more on prevention regardless of the introduction of new sites of action.

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Weeds (agrestal and ruderal) utilization in livestock treatments from Moradabad, India

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Livestock is an important sector of agriculture in Moradabad District, Uttar Pradesh. It brings cash income to the farmers and rural families, bringing protection against the social depressions in addition to providing the food products of high nutritional value. Weeds with the crop plants and affect the crop quality and quantity. For the care of animals, there has long been a traditional approach known as ethno-veterinary medicine which includes concepts, knowledge, conventions, and knowledge related to healthcare and cattle management. Many people, particularly in the Moradabad district, relied on farming and livestock, like as cattle, buffalo, sheep, goats, and poultry. The livestock is now affected by diseases brought on by pollution, global warming, and other factors. Nowadays, hospitals are everywhere, yet some places, like rural areas, don't have access to such services. Therefore, it is common procedure to employ local weed herbs as a cure for ailments including enteritis, maggot wounds, fractures, tympani, black quarter, mouth ulcers, and foot infections. This paper explored, some common locally used ethno-veterinary weed plants from Moradabad district, Uttar Pradesh, India. Certain of the ethno-veterinary practices of using weeds in different blocks of Moradabad district, particularly rural areas, were recorded by visiting and collecting all information about weed plants. In this study we have discussed ethno-veterinary uses of weeds, mode of administration; doses and duration of 58 weed plant species belonging to 31 families for treating routine maladies of livestock of Moradabad district. Total 58 angiosperm weeds were reported from all the sampling sites. The top 10 families of weeds out of 31, the predominance was shown by family Poaceae having 06 weeds followed by Apocynaceae, Asteraceae, Amaranthaceae, Euphorbiaceae and Solanaceae each 04, Lamiaceae, Fabaceae each with 03 species and Acanthaceae, Nyctaginaceae each with 02 weed species. Recorded weeds were mostly related with Lamiids 17, followed by Fabids 13, Commelinids 08, Superasterids 08, Campanulids 5, Malvids 03, Rosids, Eudicots, Monocots, ANA each 01 different grades of Angiosperm phylogeny group (APG)-IV. The weeds were reported to be used mostly in the utilization of weeds in skin (14%) ailments, galactogogue (14%) followed by dysentery (11%), diarrhoea (11%), eye ailment (11%), placenta removal (9%), constipation and maggot infection (7%), and mouth infection (5%). Mostly weeds as per plant life form were herbs (71%) followed by shrubs (16%), undershrubs (7%), creeper and climber (3%) life forms. Mostly weeds as plant part used for different types of ailments of livestock were leaves (42%), followed by whole plants (20%), root (13%), fruit (4%), seeds (10%), latex (4%), flower (2%), rhizome (3%) and stem (2%). In this paper the families of concern weeds plant are reported according to the APG-IV system. This paper represents that the maximum weed species are related with the Poaceae family of Commelinids grade of APG-IV.

TECHNICAL SESSION 10

Weed biology, ecology and climate change

Habitat, distribution and germination ecology of *Leptochloa chinensis*, a weed of potential threat to the rice crop production in Kerala, India

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Leptochloa chinensis, also known as 'Chinese sprangletop' is a C4 grass weed native of tropical Asia. In Kerala, it was earlier confined to the alkaline soils of Chittoor taluk as a weed specific to alkaline conditions. Of late, severe infestation of this weed has been observed in the major rice growing tracts of Kerala. In this context, an investigation entitled 'Germination ecology and management of Chinese sprangletop [*Leptochloa chinensis* (L.) Nees.] in wet seeded rice' was undertaken at Kerala Agricultural University, Thrissur, Kerala during 2017-2020. A phytosociological survey was conducted to document the habitat, composition and distribution of *L. chinensis* in different rice tracts of Kerala, *viz*. Palakkad, *Kole* and Kuttanad after selecting three severely infested padasekharams in each tract during 2018 and 2019. *L. chinensis* was found to occur in all the major rice growing tracts of Kerala and registered summed dominance ratio of 13.05, 12.40 and 17.49, respectively in Kuttanad, Kole and Palakkad (*Kharif*). Appraisal of weed vegetation analysis indices displayed the highest weed species richness (17) and Simpson's diversity index in *Kole* and the lowest Shannon Wiener diversity index (2.09) in Palakkad. *L. chinensis* was the dominant weed in all these tracts with an abundance of 17.33, 17.0 and 16.36, respectively and the weed inhabited both upland and lowland situations, either in crop lands, field bunds, stream banks or waterways. Profuse growth of the weed was observed along the inner bunds separating individual fields. The weed was a prolific seed producer with seed production potential ranging from 7400-33,941 seeds per plant across the surveyed locations. Investigations on germination ecology revealed that light was not an absolute requirement for germination of seeds of *L. chinensis,* but stimulated germination by 23%. When exposed to alternating temperatures in light/dark, seeds germinated at 15°C to 35°C. The highest germination occurred at 25/15°C (87.2%), while at 35/25°C it was only 70.31%. Germination of *L. chinensis* was significantly influenced by moisture regime; with zero germination under continuous flooding or with thin layer of water (3 cm) and 70% germination on irrigating at alternate days. Seedling emergence was also significantly affected by seed burial depth. Seedling emergence was high (85%) for seeds placed on the soil surface, while no emergence was observed at burial depths of 2 cm or beyond. Slips placed at the surface recorded 100% sprouting and the time taken for 50% emergence increased with increase in burial depth. The seeds germinated up to nine months after harvest with the germination declining over time. The study identified *L. chinensis* as a major weed in all the major rice growing tracts of Kerala indicating its invasive potential under diverse environmental conditions owing to its prolific seed production, sprouting from weed slips on soil surface, extended period of seed viability and different mode of propagation. The results revealed that early and continuous flooding, deep tillage for burial of seeds and slips into the soil beyond 5 cm could suppress its emergence.

Maternal environmental effects on germination and seedling growth of seeds produced by summer and winter cohorts of an invasive weed *Parthenium hysterophorus*

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The earliest stages of development of plants such as seed, rate of seed germination is influenced by not only the immediate environment of the seeds but also by the environment experienced by mother plant before the seed dispersal, often referred to as maternal effects. In this study, seed germination and biomass allocation in seedlings produced by summer (hot and humid climate) and winter (cold and dry) cohorts of *Parthenium hysterophorus*, a noxious invasive weed of tropical and subtropical world, in Kathmandu valley (Nepal) were analyzed to understand the maternal environmental effects on their offsprings. Germination was observed under alternating day/night temperatures (low: 25/15˚C, high: 30/20˚C), light (12-h photoperiod of 3000lux and complete dark) and water stress (-0.1, -0.25, -0.5, -0.75 and -1MPa induced by PEG6000 solution) for 20 days. Seed mass, germination percentage (GP), Timson index (TI) and mean germination time (MGT) were calculated. Similarly, biomass allocation was studied by growing seedlings in greenhouse with average temperature and light intensity of 27 °C and ca. 5163 lux. Relative growth rate (RGR), root mass fraction (RMF), stem mass fraction (SMF), leaf mass fraction (LMF) and root shoot ratio (RSR) were determined. Winter seeds had higher seed mass (0.048 ± 0.002g) than summer seeds (0.036 ± 0.001g). Although seeds of both cohorts could germinate under complete dark, germination percentage was higher by 10-18% under a 12-h photoperiod. At low temperature (25/15˚C), winter seeds showed high GP (88%), TI (1379), and MGT (5 days) compared to summer seeds (49%, 841 and 4 days, respectively). But, at high temperature (30/20˚C), summer seeds showed high GP (100%) and TI (1853) compared to winter seeds (96%, and 1379 respectively). Seed germination of both the cohorts decreased with increasing water stress (lower water potential). About 2.67% of winter seeds germinated at -0.75 MPa but summer seeds were unable germinate beyond -0.5 MPa. Similarly, the results of seedling biomass allocation indicated that, winter seeds have higher RGR (76.8 $mg.g^{-1}day^{-1}$) than summer seeds (72.7 $mg.g^{-1}day^{-1}$). The RMF and RSR of winter seeds were found to be 0.14 and 0.16, respectively which was higher as compared to summer cohorts (0.11 and 0.12, respectively). Similarly, the SMF and LMF of summer seeds was found to be 0.21 and 0.638, respectively which is almost like that of winter seeds (0.21 and 0.610). This experiment provides evidence of strong impacts of the maternal environment on seed germination but less impact on seedling growth. Moreover, the results also suggest a wide range of environmental tolerance (cold and dry winter to hot and humid summer) during seed germination of *Parthenium hysterophorus* which might have allowed the plant to grow both during the winter and summer seasons.

Germination ecology and seedling growth of congeneric native and invasive *Mimosa* species

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Comparisons of germination behaviour and growth performance between native and invasive congeners are potentially useful approaches for identifying characteristics that promote invasiveness. We compared seed attributes (size, mass, seed coat permeability), germination under different environmental conditions [12h photoperiod/complete dark, high (30/20°C)/low (25/15°C) temperature, water stress (induced by PEG6000 solutions)], seedling emergence, and seedling growth (biomass allocations, relative growth rate (RGR)) of highly invasive *Mimosa diplotricha* var. *diplotricha* and *Mimosa diplotricha* var. *inermis* with its congeneric native *Mimosa himalayana* growing under the same climatic condition in south-eastern Nepal. Germination data was used to calculate germination percent, mean germination time and Timson's index. Freshly collected seeds of all species did not imbibe water suggesting that seed coat was impermeable to water. Seeds germinated following hot water scarification which indicates physical dormancy. The scarified seeds germinated equally under complete dark (98, 98 and 100% respectively of *M. himalayana*, *M. diplotricha* var. *diplotricha* and *M. diplotricha* var. *inermis*) and 12 h photoperiod (95, 96 and 100%). In each species, there was no significant difference in seed germination maintained under low (*M. diplotricha* var. *diplotricha*: 96%; *M. diplotricha* var. *inermis*: 100%; *Mimosa himalayana*: 95%) and high temperature regimes (*M. diplotricha* var. *diplotricha*: 97%; *M. diplotricha* var. *inermis*: 99%; *Mimosa himalayana*: 91%). Germination percent and rate of both congeners declined as water stress increased, but the decline was more pronounced in native species. Seeds of both congeners germinated well up to water potential of -0.5MPa and beyond this, no germination was recorded in both varieties of *M. diplotricha*, while 2% seeds germinated in *M. himalayana*. All of the analyzed germination parameters, with exception of mean germination time, were comparatively higher in invasive species than in native species. Seedlings of invasive species were taller with higher numbers of leaves and greater allocation of biomass to shoot, while native species allocated greater proportion of biomass to root. The RGR was higher by almost two times in invasive species (74mg/g/day and 70mg/g/day respectively in *M. diplotricha* var. *diplotricha* and *M. diplotricha* var. *inermis*) than it was in native species (40mg/g/day). Seedling emergence declined with increasing depth and no seedling emerged beyond 4 cm depth in both species. The performance of invasive species was better than of native congener in terms of germination and seedling growth under identical conditions suggesting that the traits related to seed germination and growth can be useful for the prediction of invasiveness of species in their introduced range.

Floristic diversity and phytosociology of weeds in rice fields of village-Khajuri under Takhatpur block, Bilaspur district, Chhattisgarh

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The information and knowledge about diversity and distribution of weeds is powerful source for designing weed management. The present study deals with the diversity of weed flora and their phytosociology. This study was conducted in rice fields of village Khajuri under Takhatpur block, Bilaspur district, Chhattisgarh during 2019-2021. The soil of this area is black soil locally called '*Kanhar*' and sandyloam locally called '*Matasi*'. Both are well suited and ideal for rice crop. For the phytosociological study of weeds random quadrat method was applied. Fifty quadrats having size of 1m x1m were laid down in the rice crop fields. Phytosociological parameters like frequency, density, abundance, relative frequency (RF), relative density (RD), relative dominance (RDom) and importance value index (IVI) was calculated for each weed species. It was found that rice fields were infested with 66 weeds belonging 20 families (Acanthaceae, Amaranthaceae, Asteraceae, Commelinaceae, Convolvulaceae, Cyperaceae, Euphorbiaceae, Fabaceae, Linderniaceae, Lythraceae, Malvaceae, Marsileaceae, Onagraceae, Oxalidaceae, Plantaginaceae, Poaceae, Potulacaceae, Solanaceae, Tiliaceae and Verbinaceae). Sixteen families, 33 genera and 37 weeds belonged to dicot and 03 families, 19 genera and 28 weeds to monocot families and 01 pteridophytic species occurred. In the study dicot and monocot ratio was recorded as 5.33, genera wise and species wise ratio was respectively 1.73 and 1.32. The weed flora was found to be dominated by family Cyperaceae with 11 weeds and Poaceae with 14 weeds. Weeds belonging to monocot families dominated. On the basis of importance value index (IVI), it was recorded that the ten most dominant weeds were: *Echinochloa colona* (L.) Link with highest IVI 28.75, *Paspalum scrobiculatum* L. (IVI 25.90), *Cyperus difformis* L. (IVI 23.85), *Fimbristylis miliacea* (L.) Vahl (IVI 21.30), *Cyperus iria* L. (IVI 15.46), *Alternanthera tenella* Colla (IVI 13.14), *Ischaemum rugosum* Salisb (IVI 10.59), *Cynodon dactylon* (L.) Pers. (IVI 09.95), *Ammannia baccifera* L. (IVI 08.41) and *Ludwigia perennis* Burm.f. (IVI 07.64). These are known to cause heavy yield losses due to competition with rice. Their ecological status in terms of their phytosociological characters show a clear-cut trend of dominance. *Echinochloa colona* was reported as one of the most dominant weed species in rice fields of village Khajuri. The present study revealed important information and knowledge about the presence, composition, diversity and distribution of weed species. This knowledge gained by this study may help in designing weed management programme.

Influence of different cropping systems on phytosociology and diversity of weeds under mid hill conditions of Himachal Pradesh

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The study was carried out in a continuing experiment under the natural farming at CSK HPKV, Palampur during 2019-20. Nine cropping systems C_1- Maize – wheat, C_2- 'Blackgram-wheat + gram', C_3- 'Soybean - wheat + lentil', C_4- 'Cow pea - wheat + sarson', C_5- 'Okra - wheat + pea', C_6- 'Maize + blackgram – Gram', C_7- 'Maize + soybean – lentil', C_8- 'Maize + cow pea – sarson', C_9- 'Maize + okra – peas' in a randomized block design with three replications were evaluated for appraisal on weeds phytosociology and floristic diversity. Soil of experimental field was silty-clay loam in texture and acidic in reaction with medium organic carbon. The soil was low in available nitrogen and potassium and medium in phosphorus. The total amount of rainfall received was 638 mm and 1497 mm in both *Rabi* and *Kharif* seasons, respectively. The weeds count was recorded at 30 days interval after sowing crops in the experimental field under different cropping systems. For weeds count, a quadrat with an area of 0.25 m^2 was placed randomly between border rows at two places in each plot. Weed flora was composed of 13 species in *Rabi* and 15 species during *Kharif*. *Lolium temulentum* (37%), *Phalaris minor* (18%), *Avena ludoviciana* (15%), Vicia *sativa* (7%), *Plantago lanceolata* (5%), *Coronopus didymus* (4%), *Bidens pilosa* (4%) and *Poa annua* (3%) were the major weeds during *Rabi*. *Cyperus iria* (24%) was the most dominant weed followed by *Echinochloa colona* (22%), *Digitaria sanguinalis* (17%), *Ageratum conyzoides* (14%), *Brachiaria reptans* (7%), *Polygonum alatum* (7%), *Panicum distichum* (3%), *Commelina benghalensis (2%) and Trifolium repens (2%)*. Important value index (IVI) is a standard tool used to assess the overall significance of a species under a particular crop-weed environment and can be obtained by summing up relative density, relative frequency and relative abundance. *Lolium temulentum* had highest relative density, relative frequency and relative abundance and was the most important weed during the *Rabi* season with IVI value ranging from 33.8 to 57.3 under different cropping systems. This was followed by *Phalaris minor*, *Avena ludoviciana* and *Vicia sativa*. During *Kharif, Cyperus iria* was the most important weed with IVI value of 40.9-69.8 in cropping systems. This was followed by *Echinochloa colona*, *Digitaria sanguinalis* and *Ageratum conyzoides*. Shannon Weiner index accounting for order or abundance of a species within a sample plot was highest under maize – wheat (C_1) followed by maize – wheat + lentil (C_7) in *Rabi* and blackgram – wheat + gram (C_2) followed by sole maize – wheat (C_1) in *Kharif*. Simpson's index of diversity and Simpson's reciprocal index indicated higher weed diversity under maize + soybean -lentil (C_7) followed by maize + cowpea - sarson (C_8) and blackgram – wheat + gram (C_2) followed by okra – wheat + pea (C_5) in *Rabi* and *Kharif*, respectively.

Emergence time and density of *Phalaris minor* Retz effects its economic threshold level in wheat

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Phalaris minor has been a major threat to productivity and sustainability of rice-wheat system in NW India. and under severe conditions, it can be a sole cause of complete crop failure which was fairly common during late 1970's due to the absence of effective herbicide and, in mid-nineties, after it evolved resistance against isoproturon. The knowledge of threshold level of weed infestation can be utilized to reduce herbicide use. With this perspective, the study was planned to estimate yield losses in wheat caused by *P. minor* competition as a function of its density and time of emergence, and to determine its economic threshold level in wheatA field experiment was carried out on a sandy loam soil during winter season of 2019-20 and 2020-21 at Punjab Agricultural University, Ludhiana, India. The treatments consisted of five timing of emergence of *P. minor* (0, 14, 28, 42 and 56 days after wheat emergence, d) in main plots and five *P. minor* densities (0, 5, 15, 45 and 135 plants/m^2) in sub plots in a split plot design with three replications. In 0 days after wheat emergence (d), *P. minor* seeds were sown as per density on the day of wheat sowing. In 14 and 28 d treatments, seeds were sown one week before due date of emergence while in case of 42 and 56 d treatments, *P. minor* seeds were sown 12-day before due date of emergence. *Phalaris minor* emerged along with wheat (0 d) recorded highest values for all growth and reproductive attributes. Each delay in emergence of *P. minor* from 0 through 28 d resulted in significant reduction in plant dry biomass, spikes/plant and seeds/spike. *P. minor* plants emerged at 42 and 56 d did not survive till crop harvest. *P. minor* emerged at 14 d accumulated 43% lower plant dry biomass than 0 d; delay in emergence from 14 to 28 d further reduced its dry biomass by 23%. *P. minor* plant density showed variable effect on its growth and reproductive attributes. In case of plant dry biomass, there was significant increase with every increase in density from 5- 135 plants/m^2. And, at each *P. minor* density, dry biomass was significantly reduced with each delay in emergence from 0-28 d. In case of seed number/spike, at each emergence time, it did not show any consistent trend with respect to plant density. However, at each *P. minor* density, there was significant reduction in seed number/spike with every delay in *P. minor* emergence from 0-28 d. When *P. minor* emerged at 0 d, it produced higher seed number/spike at densities from 5 to 45 than 135 plants/m^2.Each delay in emergence of *P. minor* from 0 through 42 d resulted in significant increase in wheat grain yield. When *P. minor* emerged at 0 and 14 d, wheat grain yield was significantly reduced even at 5 plants m^{-2} compared to weed free. The economic threshold levels of *P. minor,* for achieving 95% of potential wheat yield level, turns out to be 0, 6, 24, 103, and 331 plants/m^2, respectively, when *P. minor* emerged at 0, 14, 28, 42 and 56 days after wheat emergence. Hence, any management practice for *P. minor* must delay its emergence and minimize its density till 42 days after wheat emergence for minimizing losses in wheat grain yield.

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Taxonomic influence on diversity in seed dormancy and its breaking methods in globally important weed species

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Seed dormancy is the inability of a viable seed to germinate even under favourable conditions. It can be of a variety of forms, such as innate, induced, and enforced dormancy. Seed dormancy is an evolutionary critical trait that sustains species persistence by restricting seed germination under unfavourable ecological conditions that would normally allow a poor likelihood of seedling survival. Owing to the variable magnitude of seed dormancy, weed seeds hibernate in the soil seedbank and emerge periodically over many years, jeopardising the application timing of weed control strategies across global cropping systems. Understanding weed seed dormancy cycle is critical as to optimise the execution timing of available weed control strategies and resources without interfering with the cash crop growth and development. To this effect, we reviewed 98 research studies conducted across five continents that included 50 globally important weed species from 18 taxonomic families. In this preliminary data mining, *Poaceae* and *Asteraceae* family weed seeds were found to be more dormant than seeds from other families, with most weed species having a fresh seed dormancy of 90-100%. *Panicum dichotomiflorum*, a summer annual *Poaceae* weed, was found to show the greatest seed dormancy (93-100%). In laboratory condition, seed dormancy release by external treatments substantially varied according to the taxonomic family. The *Poaceae* weeds mostly released seed dormancy in exposure to incubation at high temperatures and/or with red light irradiation and imbibition or scarification using a number of chemicals such as potassium nitrate, gibberellic acid, and sulfuric acid. Whereas cold stratification (4!) and gibberellic acid under dark conditions were commonly used methods for breaking seed dormancy in the *Amaranthaceae* family. Such a data base, once finalized, will help devising and incorporating appropriate seed dormancy breaking treatments into an integrated weed management strategy, which will aim to stimulate the weed seeds to germinate during pre-planting operations and be killed using pre-emergence herbicides. This will help in effective weed management by exhausting the weed seedbank and reducing the number of post-emergence herbicide applications, ultimately lessening the financial burden on farmers.

Relative density and frequency of weed seeds in weed seed bank on different time of ploughing at various depth of soil

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Weed seed bank constitute of many numbers of weed seeds and species for future population at different depth of the soil. This can be influenced by the tillage operation which was carried out during the field preparation. The composition of seed bank will be varied at different depth of soil at various time of ploughing. The lab experiment was conducted in Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore to evaluate the relative density and frequency of weed seeds in weed seed bank on different time of ploughing at various depth of soil**.** The experiment was laid out in completely randomized block design with five replications. The soil samples were collected from different depth of the soil, *viz.*, 0-5 cm, 5-10 cm, 10-15 cm and 15-20 cm during before and after ploughing of the field. The field was ploughed using the implements five Tyne cultivator followed by nine Tyne cultivator and rotovator. The seeds of 11 weed species were detected from the collected soil samples, *viz.*, *Trianthema portulacastrum, Echinochloa colona, Digera arvensis, Amaranthus viridis, Acalypha indica, Dinebra retroflexa, Bracharia reptans, Chloris barbata, Dactyloctenium aegyptium, Corchorus capsularis* and *Boerhavia erecta.* Among the eleven identified weed species, *Trianthema portulacastrum* recorded the higher relative density of 28.56% and 31.34% at before and after ploughing, respectively in the depth of 0-5 cm and it was followed by *Echinochloa colona.* The same trend was observed in all the depth of soil during before and after ploughing. The lower relative density was recorded for *Boerhavia erecta* (0.88%) in the depth of 0-5 cm, *Bracharia reptans* (0.16%) in the depth of 6E0 cm, *Bracharia reptans* (0.26%) in the depth of 11-15 cm and *Amaranthus viridis* (0.38%) in the depth of 16-20 cm, before ploughing. After ploughing, minimum relative density of 1.01% for *Boerhavia erecta*, 1.35% for *Dinebra retroflexa*, 0.88% for *Chloris barbata* and 0.67% for *Dinebra retroflexa* at the depth of 0-5 cm, 6-10 cm, 11-15 cm and 16-20 cm, respectively. The higher relative frequency was recorded for *Trianthema portulacastrum* and *Echinochloa colona* which was followed by *Digera arvensis* in all the depth of soil during before and after ploughing. *Boerhavia erecta* registered lower relative frequency at the depth of 0-5 cm soil during before and after ploughing. At before ploughing, *Bracharia reptans* registered lower relative frequency at the depth of 6-15 cm and *Amaranthus viridis* at the depth of 16-20 cm. After ploughing, at the depth of 0-5 cm *Dinebra retroflexa* registered lower relative frequency at 6-10 cm and 16-20 cm and *Chloris barbata* at the depth of 11-15 cm. Hence, the seed bank was dominated with the population of *Trianthema portulacastrum* followed by *Echinochloa colona* at all the depth of the soil. The management has to be carried out to control the population of dominant weed species in the seed bank before crop production in the field.

Ecology of seed dormancy and germination in sedges

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Rice (*Oryza sativa L.*) is the staple food for more than 60%of the world population and its cultivation secures a livelihood for more than two billion people. Weed infestation is one of the major constraints affecting the production of rice. Among the different groups of weeds, *cyperus* family weeds severely affect the food grains which are *Cyperus iria*, *Cyperus difformis*. These weeds are widely naturalized all over the world. Especially they are more problematic in countries like America, southern/central Europe, South Asia and Africa. It significantly impacting subtropical and tropical agro-ecosystems in both hemispheres. *Cyperus difformis* (flat sedge) is a native of the Old World tropics and is now widespread throughout southern Europe, Asia, Central America, North America, Africa and the islands of the Indian and Pacific oceans. This sedge can become a major weed in rice, particularly, where herbicides are used to control grass weeds but are not effective against sedges like *C. difformis*. The ability of the species to complete a vegetative and reproductive cycle within a month or so makes it especially competitive in a crop that requires at least 90 or more days to reach maturity. Specific knowledge about the dormancy, germination, and emergence patterns of weed species aids the development of integrated management strategies. The present study was carried out to study the gerrmination pattern of *cyperus difformis*. The experimental design was laid out in Completely Randomized Design with three replications. Which conists of T_1- control, T_2- GA_3 200 ppm for 6 hrs soaking, T_3- GA_3 200 ppm for 12 hrs soaking,T_4- GA_3 200 ppm for 18 hrs soaking, T_5- GA_3 400 ppm for 6 hrs soaking,T_6- GA_3 400 ppm for 12 hrs soaking,T_7- GA_3 400 ppm for 18 hrs soaking,T_8- GA_3 600 ppm for 6 hrs soakingT_9- GA_3 600 ppm for 12 hrs soaking,T_{10}- GA_3 600 ppm for 18 hrs soaking,T_{11}- KNO_3 0.5% for 6 hrs soaking,T_{12}- KNO_3 0.5% for 12 hrs soaking,T_{13}- KNO_3 0.5% for 18 hrs soaking, T_{14}- KNO_3 1.0% for 6 hrs soaking,T_{15}- KNO_3 1.0% for 12 hrs soaking,T_{16}- KNO_3 1.0% for 18 hrs soaking,T_{17}- thiourea 0.5% for 6 hrs soaking,T_{18}- thiourea 0.5% for 12 hrs soaking,T_{19}- thiourea 0.5% for 18 hrs soaking,T_{20}- thiourea 1.0% for 6 hrs soaking,T_{21}- thiourea 1.0% for 12 hrs soaking,T_{22}- thiourea 1.0% for 18 hrs soaking,T_{23}- distilled water for 6 hrs soaking,T_{24}- distilled water for 12 hrs soaking,T_{25} – distilled water for 18 hrs soaking. The physiological treatments were able to improve germination. Among the physiological treatments, GA_3 600 ppm for 12 h soaking recorded the highest germination of 92%.

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Study on shift in weed flora in sugarcane under changing climate scenario

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A field study was conducted at Main Sugarcane Research Station, Junagadh Agricultural University, Kodinar, Gujarat, India during 2017-18 and 2018-19 to identify the weed flora, their intensity and frequency in sugarcane fields under changing climate scenarios. For this purpose, a weed survey of sugarcane crop was carried out in the newly constituted Gir Somnath district of South Saurashtra region of Gujarat as majority of sugarcane growing area lies in this region. All six talukas (Veraval, Sutrapada, Kodinar, Talala, Una and Gir Gadada) of Gir Somnath district had been covered during the survey. A total of 30 sugarcane-growing villages were selected from these six talukas and five sugarcane fields were selected in each village. In this survey, 150 fields were covered during the survey. Each sugarcane field was visited twice, once in winter and once in the summer season during 2017-18 and 2018-19. Surveys were conducted at a time when most weeds were observable. Three quadrats (0.5 m x 0.5 m) were placed randomly in each sugarcane field. The same village and farmer's field were selected for the second year of the survey. The survey study indicated the dominance of thirty-nine weed species, belonging to 14 families, in sugarcane fields. Their important index values, density (%) and frequency (%), were worked out. On the basis of density, *Brachiaria ramosa* (L.) Stapf. was the most dominant and frequent weed-species in majority of the selected fields, with average percentage of 21.82%. It was followed by *Cyperus rotundus* L., *Brachiaria reptans* Gard. & Hubb, *Portulaca oleracea* L., *Digera arvensis* Forssk., *Setaria viridis* (L.) P. Beauv., *Cynodon dactylon* (L.) Pers., *Parthenium hysterophorus* L., *Indigofera glandulosa* L., *Physalis minima* L., *Commelina benghalensis* L., *Euphorbia hirta* L., *Chenopodium album* L., *Echinochloa colonum* L., *Corchorus olitorius* L., *Amaranthus viridis* Hook. F., *Elurops veelosus* with the percentage ranging from 10.27 to 1.33%. The other weeds, like *Dicanthium annulatum, Vernonia cinerea* (L.) Less., *Eragrostis pilosa* L. P. Beauv, *Argemone maxicana* L., *and Merremia gangentica* (Linn.) Cufod. were observed less dominant in the study area. The frequency observations also indicated *Brachiaria ramosa* (L.) Stapf. as the most frequently occurring weed species, with a percentage of 74.50% in selected fields of sugarcane. The other species with higher frequency of occurrence were: *Portulaca oleracea* L., *Cyperus rotundus* L., *Brachiaria reptans* Gard. & Hubb, *Digera arvensis* Forssk., *Setaria viridis* (L.) P. Beauv., *Physalis minima* L., *Euphorbia hirta* L., *Parthenium hysterophorus* L., *Indigofera glandulosa* L., *Commelina benghalensis* L., *Cynodon dactylon* (L.) Pers., *Chenopodium album* L., *Echinochloa colonum* L., *Corchorus olitorius* L., and *Elurops villosus* with frequency ranging from 45.56 to 12.22%. The less common weed-species were *Dicanthium annulatum, Eclipta prostrata* (Linn.) Linn., *Argemone maxicana* L., *Vernonia cinerea* (L.) Less., *Achyranthes aspera* L. and *Eragrostis pilosa* L. P. Beauv with frequency percentages ranging from 0.06 to 0.28%.

Insight into the physiological and biochemical mechanisms of salt, drought, and arsenic stress tolerance in two contrasting ecotypes of *Chenopodium album*

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Chenopodium album (commonly called lambsquarters or white goosefoot) is a widely adapted weed species facing a wide range of adverse environmental conditions during its growth and developmental phases. Salinity, drought, along with arsenic stress are some of those significant environmental threats that can disrupt the physiological and biochemical responses of plants. The current study was conducted to investigate the morpho-physiology, osmotic adjustment, oxidative stress, antioxidant defense, and methylglyoxal detoxification of two *C. album* ecotypes (green and red) under salinity, drought, and arsenic stress. To explore the significant influence of salinity, drought, and arsenic stress and their responses, 40-day-old *C. album* ecotypes were subjected to drought, viz. moderate (15% soil moisture) and severe (5% soil moisture) drought, salt stress, viz. 500 and 1000 mM of NaCl, and arsenic stress, viz. 1 and 2 mM of sodium arsenate. Although compared to control, drought stress reduced fresh, dry weight, leaf greenness, relative water content; increased proline (Pro) content and oxidative stress indicators (malondialdehyde and hydrogen peroxide contents) along with enhanced antioxidant and glyoxalase systems in both ecotypes, red ecotype seemed to be more drought-tolerant than the green one. Similar trends were also noticed in the case of salinity and arsenic stress. The non-enzymatic and enzymatic components of the ascorbate-glutathione (AsA-GSH) pool in both ecotypes were disrupted under all stress conditions, resulting in an imbalance in the redox equilibrium. In contrast, compared to the green ecotype, green ecotype revealed a lower Na^+/K^+ ratio, higher levels of ascorbate (AsA), dehydroascorbate (DHA) and glutathione (GSH) contents, lower glutathione disulfide (GSSG) contents and a higher ratio of AsA/DHA and GSH/GSSG, whereas enzymatic components such as monodehydroascorbate reductase (MDHAR), dehydroascorbate reductase (DHAR), glutathione peroxidase (GPX) and glyoxalase enzymes were increased. The findings demonstrated a relationship between a higher Pro content, a lower Na^+/K^+ ratio, enhanced glyoxalase system performance, and antioxidant protection for scavenging reactive oxygen species in red ecotype compared to the other one under all stressors. It may be concluded that antioxidant defense plays a vital role in conferring abiotic stress tolerance in *C. album*. These findings can help us predict how different environmental stress responses will affect *C. album* ecotypes.

Comparative morphophysiology, ion homeostasis, water relations and antioxidant metabolism in *Chenopodium quinoa* and *Chenopodium album* in response to salinity and drought

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Plant response and adaptation to different environmental stresses like salinity, drought, waterlogging involves a wide spectrum of cellular, physiological, and biochemical changes, and it is essential to unravel these mechanisms to adopt an efficient strategy to alleviate such stresses. Salinity and drought adversely affect the growth and metabolic activities of plants by inducing dehydration and ionic toxicity as well as being responsible for inducing oxidative stress in plants. Therefore, the aim of the current investigation was to compare the biochemical responses of *Chenopodium quinoa* and *Chenopodium album* subjected to salinity and drought. Thirty-day-old *C. quinoa* and *C. album* seedlings were exposed to salt stress by irrigating 500 mM NaCl, and drought by maintaining soil moisture of 15%. The relative water content was notably declined in *C. album* under drought and in response to this osmotic shock, the *C. album* accumulated a higher amount of proline as osmoprotectant. Similar response was also observed in the *C. quinoa* under drought, but the proline accumulation was less compared to the *C. album*. Moreover, the *C. album* showed greater susceptibility to drought-induced oxidative stress indicated by higher malondialdehyde and hydrogen peroxide content, on the other hand, the *C. quinoa* appeared to suffer lesser damage as evidenced by lower accumulation of malondialdehyde and hydrogen peroxide under drought. The antioxidant defense system of *C. quinoa* and *C. album* were greatly hampered under salt stress and drought. In the drought-affected *C. quinoa*, the ascorbate and ascorbate/dehydroascorbate ratio declined more prominently, whereas the reduction of glutathione and glutathione/glutathione disulfide ratio was found under salt stress. The activities of ascorbate peroxidase, superoxide dismutase, and peroxidase were increased in both *C. quinoa* and *C. album* under salt stress and drought. On the contrary, upon exposure to salt stress and drought, the activities of monodehydroascorbate reductase, dehydroascorbate reductase, glutathione reductase, glutathione peroxidase, glutathione *S*-transferase, and catalase were declined in both *C. quinoa* and *C. album*, however, reductions were more noticeable at the drought affected plants. Salt stress and drought also accelerated the accumulation of methylglyoxal in both *C. quinoa* and *C. album* due to the declination of the activities of glyoxalase I and glyoxalase II enzymes. The *C. quinoa* accumulated higher amounts of Na^+ and lowered K^+, thus the ratio of Na^+/K^+ was also increased under salt stress. Thus, the findings of the current study indicated that both *C. quinoa* and *C. album* are more susceptible to drought than salt stress.

TECHNICAL SESSION 11

Weed management in cash crops and minor crops

Combined effect of tillage and weed management on weed population and productivity of cotton – baby corn cropping system under conservation agriculture

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Cotton is an important fibre crop widely cultivated throughout India under both rainfed and irrigated conditions. In Tamil Nadu, western agroclimatic region constitute major area under cotton crop. The major constraints encountered are: inadequate crop stand due to poor emergence after sowing, increased incidence of pests and diseases particularly weeds. Weed control is the biggest challenge to conservation agriculture adoption. Changes in tillage methods can affect weed population dynamics, weed seed distribution and abundance in soil seed bank. Tillage system and crop rotation have significant long-term effects on soil productivity and quality such as soil carbon and other soil physical, biological and chemical properties. The conservation tillage methods combined with effective weed control method is to be identified for higher productivity of cropping system. Field experiments were conducted during Baby corn crop during *Rabi*, 2021 in long term conservation agriculture experiments and cotton crop in long term conservation agriculture experiments during *Kharif* 2021 were conducted at TNAU, Coimbatore and laid out in a split plot design with three replications. Treatments consists of three types of tillages, *viz.*, Conventional tillage, zero tillage with or without residues as main plot and sub plot consists of weed management options, *viz.*, PE Diuron 750 g/ha fb EPOE Pyrithiobac sodium 75g/ha at 20-25 DAS, recommended herbicides (PE Pendimethalin (CS) 680g/ha *fb* directed spray of paraquat 0.6 kg/ ha, EPOE Topramezone 12.5 g/ha + 2,4 D 500 g/ha at 20-25 DAS and PE Atrazine 1.0 kg/ha + BC on 45 DAS.Higher weed control efficiency of 78.7% was recorded in CT- ZT- ZT system. Among weed management practices, EPOE Topramezone 12.5 g/ha + 2, 4 D 500 g/ha at 20-25 DAS recorded higher weed control efficiency (81.3%). Significantly, higher grain yield of 4902 kg/ha was recorded with (ZT+(R)- ZT+(R)- ZT+(R). EPOE Topramezone 12.5 g/ha + 2, 4 D 500 g/ha at 20-25 DAS significantly recorded higher yield 7223 kg/ha in baby corn. Higher weed control efficiency of 81.7% was recorded in CT+ZT+ZT system. Among weed management practices, PE Pendimethalin (CS) 680 g/ha followed by directed spray of Paraquat 0.6 kg/ha recorded higher weed control efficiency (81.3%) in cotton. Hence, Zero- tillage with residue along with recommended herbicide recorded higher productivity and profitability of the system.

Evaluating the effect of synthetic auxin herbicides on insect foraging behavior in white clover infested Turfgrass

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Honey bees and wild pollinators are estimated to contribute over $117 billion annually through improved global crop production and $8 billion annually in the US. However, the recent decline in pollinator abundance is a cause of concern for sustaining global food production. Although current data indicates pollinator decline is driven by biotic stressors, habitat loss, and competitive displacement of native arthropods by widely introduced honey bee populations, pesticides have been cited as a likely abiotic contributor that negatively interacts with other factors. Thus, commonly used pesticides have come under increased scrutiny from government regulators with regards to potential risks to pollinators. Several common weeds of managed turfgrass system attract honey bees and other pollinators. These same turfgrass systems require insecticide treatments to prevent turfgrass damage from root or foliar feeding insects. More data is needed to develop methods to prevent pollinator exposure to certain bee-toxic insecticides or other harmful pesticides. Field studies were conducted in 2021 and 2022 to evaluate the effectiveness of various herbicides on reducing pollinator foraging of white clover (*Trifolium repens* L.) blooms in managed tall fescue lawns. Three separate experiments were implemented in Blacksburg, VA as randomized complete block designs with six replications and seven treatments. Treatments included a nontreated control; MCPP; 2,4-D; dicamba; Trimec Classic™ (2,4-D, MCPP, dicamba); Speedzone™ (carfentrazone, 2,4-D, MCPP, dicamba); and a formulation blank (inert ingredients of Speedzone™). All flowers in each plot were counted and three representative flowers were photographed each morning starting one day before treatment and ending 6 days after treatment (DAT). All insect foragers observed for one minute were recorded for each plot three times each day (~10:00 am, ~1:00 pm, and ~4:00 pm). Flower quality was visually rated for three flowers in each plot and flower cover was calculated via digital image analysis each day. Honey bee (*Apis mellifera* L.) was the most common arthropod foraging white clover, followed by hoverfly (*Allograpta obliqua*), solitary bee (*Osmia* spp.), and bumble bee (*Bombus* spp.). The formulation blank did not alter insect foraging behavior compared to nontreated plots, but all herbicides reduced insect foraging equivalently with site dependence. The first site was conducted during cooler weather in early fall and honey bee visitation was reduced 56% d^{-1} on average compared to pretreatment foraging levels. In sites 2 and 3, the studies were conducted during warmer summer conditions and bee foraging declined more rapidly with a 70% reduction in honey bee foraging d^{-1} averaged over all herbicides and both summer sites. The number of blooms with apparent healthy florets declined 22% d^{-1} regardless of herbicide treatment. In nontreated or plots treated with the formulation blank, floral density did not significantly decline. Digitally assessed floral coverage declined 14% d^{-1} when treated with any herbicide and did not decline in nontreated or formulation-blank-treated plots. These data show that honey bees and other insects vacate herbicide-treated areas in less than 2 days following treatment even though loss of floral density and bloom quality metrics decline at a much slower pace of 4 to 5 days. Future research will evaluate the rate of nectar loss and alteration in ultraviolet reflectance of various species of lawn weeds following treatment with herbicides. Our goal is to develop best management practices that may help mitigate risks of pollinator exposure to harmful pesticides.

Effect of mesotrione on weeds and seed yield of fodder maize

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Maize is commonly cultivated as rainfed crop. Maximum yield loss occurs in the early stages of crop growth from 3-6 weeks before development of enough canopy to smother the weeds (Barla *et al* 2016). Atrazine is a widely used pre-emergence herbicide in maize crop because of lower cost, controls broad spectrum weeds, flexibility in application time (pre- or post-emergence) and compatibility with other herbicides. However continuous use of the herbicide causes shift in weed flora and development of resistance to herbicides mesotrione inhibits the enzyme called p-hydroxyphenyl pyruvate dioxygenase (HPPD) which show most effective in controlling annual broad-leaved weeds than grassy weeds. A field experiment was conducted at Research Farm, AICRP on Forage Crops, Department of Agronomy, JNKVV, Jabalpur (Madhya Pradesh) during *Kharif* season of the year 2019-2020. The main objective of the experiment was to find out the effect of application of mesotrione on growth, development and yield of maize. Eight treatments consisted with pre-emergence application (PE) of atrazine 1000 g/ ha, pendimethalin 750 g/ha PE and post-emergence application (PoE) of mesotrione 250 g/ha, mesotrione 300 g/ha, mesotrione 350 g/haand tembotrione 286 g/ha and hand weeding twice at 20 and 40 days after seeding (DAS) and weedy check were tested in a randomized block design with three replications. Sowing of maize cv. 'African Tall' was done on 1st July, 2019 by using the seed rate 20 kg/ha as per treatments in the rows 60 cm apart. A uniform dose of 80 kg/ha N + 40 kg P_2O_5 + 20 kg K_2O/ha was applied in all plots. Several weeds severely infested maize in weedy check plot of experimental area. In weedy check treatment, the total weed population was significantly higher than all the herbicidal treatments mesotrione 250 g/ha, mesotrione 300 g/ha, mesotrione 350 g/ha, tembotrione 286 g/ha, atrazine 1000 g/ha and pendimethalin 750 g/ha. The weed menace was minimum under hand weeding done at 20 and 40 DAS but it was marginal at 60 DAS due to emergence of weeds during later part of crops growth. Among the all-herbicides treatments, activity of atrazine 1000 g/ha PE and pendimethalin 750 g/ha PE was not effective against most of weeds but mesotrione 250 g/ha, mesotrione 300 g/ha, mesotrione 350 g/ha and tembotrione 286 g/ha controlled most of the associated weeds. The grain (2.80 t/ha) and stover (22.53 t/ha) yield were maximum with hand weeding twice at 20 and 40 DAS, which were comparable between to those obtained with the post-emergence application of mesotrione 350 g/ha (244 kg/ha and 21.80 t/ha of gain and stover yields, respectively).

Studies on bio-efficacy and phytotoxicity of ethalfluralin, a new dinitroanaline herbicide, for controlling weeds in potato

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Potato (*Solanum tuberosum* L.; Solanaceae), is the most commonly cultivated tuber crop and is the fourth most important food crop in the world, after wheat, rice and maize. Potato is susceptible to weed infestation that emerges earlier than the crop and leads to heavy losses in yield. Due to the long period from planting to its covering the inter-rows space, potatoes are not as competitive as some other crops. Weed competition in potatoes can reduce yield and potato tuber quality as well. Potato is found infested mainly with annual weeds which emerge with sprouting tubers and cause severe competition during the early stage of crop growth. Different weed management practices have been followed in potato cultivation; however, the chemical management of the weeds has become popular because of its ease, economic and effective control of the weeds. Although herbicides provide cost-effective weed control and save labor, over-reliance on herbicides with a similar mode of action can rapidly lead to development of herbicide resistance in weeds. Hence, herbicides with different mode of action are needed to avoid the problem of resistance. Hence, a field experiment was conducted during *Rabi* season of 2018-19 and 2019-20 at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, to evaluate the bio-efficacy, phytotoxicity and residue dynamics of ethalfluralin 36% EC in potato (*Solanum tuberosum* L.). The experiment comprising of nine treatments: ethalfluralin 540g/ha, ethalfluralin 630g/ha, ethalfluralin 720g/ha, ethalfluralin 810g/ha, metribuzin 525g/ha, oxyfluorfen 200 g/ha, ethalfluralin 1440g/ha, weed free and weedy check. Three replications were maintained in a randomized block design. *Coronopus didymus* and *Phalaris minor* were the major weeds constituting 31.7 and 15.9%, respectively of the total weed flora. They were followed by *Plantago spp*. (12.2), *Avena ludoviciana* (7.3), *Lolium temulentum* (6.1), *Vicia sativa* (6.1), *Trifolium repens* (6.1) and other weeds (14.6), respectively. Among herbicide treatments, pre-plant incorporation of ethalfluralin 720g/ha was as effective as ethalfluralin 810g, 1440g/ha, oxyfluorfen 200g/ha and metribuzin 525g/ha in controlling weeds in potato. Among all the pre-plant incorporation (PPI) treatments, ethalfluralin 720g and 810g/ha were the best treatments as far as weed control efficiency is concerned. Ethalfluralin 1440g/ha is also effective in controlling weeds but this also led to a reduction in yield due to adverse effects of the highest dose. Ethalfluralin 720g/ha was as effective as ethalfluralin 810g/ha, oxyfluorfen 200 g/ha, metribuzin 525g/ha and hand weeding (weed free) and resulted in significantly higher emergence count, plant height, number of leaves, dry matter accumulation at all the stages of observation along with the higher number of tubers per plant (5.87), tuber weight per plant (227.33 g), tuber yield (25.43 t/ha) and haulm yield (1.28 t/ha). There was no phytotoxicity of these treatments on crop and no residual effects on succeeding crop i.e., maize (*Zea mays* L.) Highest B:C ratio was obtained in oxyfluorfen 200g/ha and ethalfluralin 720g/ha (1.32), followed by metribuzin 525g/ha and ethalfluralin 810g/ha (1.25).

Performance of potato under different weed management practices

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A field experiment was carried out at the Instructional-cum-Research (ICR) farm, AAU, Jorhat on "Performance of potato (*Solanum tuberosum* L.) under different weed management practices", with the objectives of identifying the weed flora during the crop growth period; the best weed management practice in the crop and to understand the effect of the weed management practices on the soil physical, chemical and biological properties.A total of twelve treatments were taken for the research which included, Farmers practice *i.e.* manual weeding (T_1), Recommended practice of weed management (T_2), Weedy fallow (T_3), Mulching with water hyacinth at the rate of 6t/ha (T_4), Mulching with rice straw at the rate of 6t/ha (T_5), Mechanical Weeding with hoe at 30 days after planting (DAP) (T_6),pre-emergence application of metribuzine 500g/ha + 1 mechanical weeding (T_7),pre-emergence application of metribuzine 500g/ha + mulching with plant biomass (T_8), Mulching with lemongrass leaves (T_9), Mulching with biodegradable polythene film (T_{10}), Weedy Check (T_{11}) and Weed free check (T_{12}). The experiment was laid down in Randomized Block Design (RBD) with three replications. The soil of the experimental plot was of sandy loam texture with a pH of 5.2, available N in the medium range (288.54 kg/ha), available P_2O_5 and K_2O in low range with 25.37 kg/ha and 159.82 kg/ha, respectively. The crop received a ranfall of 59.3 mm during its growth period. The tubers of potato variety 'Kufri Ashoka' were planted on 17 November 2021 and the harvested on 17 February, 2022. All the recommended package of practices, except the weed management practices, were adopted during the experimentation.The results of the experiment revealed that the pre-emergence application of metribuzine at the rate of 500g/ha + mulching with plant biomass (T_8) has been able to control the weeds more effectively than the other treatments at the early stage of crop growth. However, during the later stage of crop growth, more effective management of weeds was seen under pre-emergence application of metribuzine 500g/ha + 1 mechanical weeding (T_7). The crop growth and yield attributing parameters showed that mulching with rice straw 6t/ha (T_5) has attained the maximum values for all the growth parameters and has yielded the highest number of tubers with a yield of 19.80 t/ha.The soil biological properties after harvest showed that the population of microbes were significantly higher in mulching with rice straw application at the rate of 6t/ha (T_5), as compared to the other treatments, with a value of 6.79 log cfu/g soil for bacterial population and 4.78 log cfu/g soil for fungal population. In terms of economics also, (T_5) showed higher values of gross return (₹ 495040/ha), net return (₹ 345050/ha) and B-C ratio (3.6).

Weed parameters and the nutrient status in soil, grain, straw and weed of transplanted finger millet as influenced by different weed management practices under lateritic soil of konkan

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The field experiment was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *Kharif* season of 2017 to investigate the, integrated weed management in *Kharif* finger millet (*Eleusine coracana* L. Gaertn) under lateritic soil of Konkan. The soil of the experimental plot was sandy clay loam in texture, acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and available potassium. The soil was leveled, well drained and uniform in depth. Weed intensity and weed control efficiency were recorded. The weed free check and oxyfluorfen PE 0.1 kg/ha followed by (*fb*) hand weeding (HW) at 30 days after transplanting (DAT) produced higher finger millet growth and yield attributes as compared to rest of the treatments of this study. Among the herbicide treatments of this study, oxyfluorfen (PE) *fb* HW at 30 DAT (T3) recorded significantly higher available nitrogen, phosphorus and potassium content (241.91, 17.20 & 250.15 kg/ha) in soil at harvest, while oxyfluorfen PE *fb* metsulfuron-methyl + chlorimuron-ethyl POE) (T7 recorded significantly lower available soil nitrogen, phosphorus and potassium content (223.36, 10.61 and 214.80 kg/ha) than the rest of the herbicide treatments at harvest. Among the herbiicide treatments of this study, oxyfluorfen PE *fb* HW at 30 DAT (T3) recorded significantly higher nitrogen content in grain (1.22%) and straw (0.44%) over rest of the herbiicide treatments. While treatment oxyfluorfen PE *fb* metsulfuron-methyl + chlorimuron-ethyl PoE (T7) recorded significantly lower nitrogen content in grain and straw (0.52% and 0.30). Among the herbicide treatments of this study, oxyfluorfen (PE) *fb* HW at 30 DAT (T3) recorded significantly higher phosphorus content in grain and straw (0.38% and 0.18%) than the rest of the treatments. While oxyfluorfen PE *fb* metsulfuron-methyl + chlorimuron-ethyl PoE (T7) recorded significantly lower phosphorus content in grain and straw (0.25% and 0.09%) than the rest of the treatments. Among the herbicide treatments tested, significantly higher potassium content in grain and straw (0.51% and 1.19%) was with oxyfluorfen (PE) *fb* HW at 30 DAT (T3) over rest of the treatments. While oxyfluorfen PE *fb* metsulfuron-methyl + chlorimuron-ethyl PoE (T7) recorded significantly least potassium content in grain and straw (0.42% and 1.10%) than the rest of the treatments. Among the all treatments tested, least total uptake of nitrogen, phosphorus and potassium (182.89, 35.96 and 85.39 kg/ha) by weeds was recorded with oxyfluorfen PE *fb* HW at 30 DAT (T3). While unweeded check (T10) recorded the higher total uptake of nitrogen, phosphorus and potassium (1773.89, 259.16 & 864.36 kg/ha) by weeds compared to all the other treatments.

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Weed dynamics and yield of transplanted finger millet as influenced by weed management practices

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Finger millet (*Eleusine coracana* (L.) Gaertn.) is a staple food crop next to rice and wheat for millions of people, who thrive under subsistence farming in dry areas like Eastren Africa, India and Srilanka. A field experiment on chemical weed management in transplanted finger millet (*Eleusine coracana* (L.) Gaertn.) was conducted at S.V. Agricultural College Farm, Tirupati campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh, India during *rabi*, 2020-21 in a randomized block design with ten weed management practices replicated thrice.The weed management treatments consisted of: pre-emergence application (PE) of alachlor 1000 g/ha (W_1), isoproturon 750 g/ha PE (W_2), pyrazosulfuron-ethyl 15 g/ha PE (W_3), pretilachlor 500 g/ha PE (W_4), Post-emergence application (PoE) of bispyribac-sodium 20 g/ha (W_5), topramezone 20 g/ha PoE (W_6), penoxsulam 20 g/ha PoE (W_7), ethoxysulfuron 20 g/ha PoE (W_8), hand weeding (HW) twice at 20 and 40 DAT (W_9) and unweeded check (W_{10}). Pre-emergence application of herbicides was done at 2 days after transplanting (DAT) and post-emergence application at 20 DAT. The predominant weed species in the experimental field were: *Digitaria sanguinalis, Dactyloctenium aegyptium, Cyperus rotundus, Trichodesma indicum, Celosia argentea, Commelina benghalensis* and others. HW twice at 20 and 40 DAT registered significantly higher weed control efficiency with lower density and biomass of all categories of weeds including total weeds. The next best treatment was pretilachlor 500 g/ ha PE which was in parity with pyrazosulfuron-ethyl 15 g/ha PE, penoxsulam 20 g/ha PoE and ethoxysulfuron 20 g/ha PoE. The density and biomass of total weeds was significantly highest with unweeded check, compared to rest of the weed management practices. The highest grain and straw yield as well as harvest index were realized with hand weeding twice at 20 and 40 DAT, which was significantly superior over rest of the weed management practices. The next best treatment was pretilachlor 500 g/ha PE, which was in parity with pyrazosulfuron-ethyl 15 g/ha PE and penoxsulam 20 g/ha PoE. Topramezone 20 g/ha PoE resulted in lower grain and straw yield which was on par with unweeded check and isoproturon 750 g/ha PE due to their phytotoxicity on finger millet. I Isoproturon 750 g/ha PE resulted in phytotoxicity rating of ‘2’ in 0-10 scale, on finger millet. Bispyribac-sodium 20 g/ha PoE, penoxsulam 20 g/ha PoE and topramezone 20 g/ha PoE resulted in phytotoxicity rating of ‘1’, ‘1’ and ‘6’ respectively in 0-10 scale. Isoproturon and topramezone 20 g/ha PoE reduced the final plant population/ m^2 by 32.28 and 56.25% respectively compared to unweeded check.

Management of *Cuscuta* in lucerne

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Lucerne or alfalfa (*Medicago sativa*) is native of South-West Asia, deep-rooted high protein containing forage crop which provides an alternative source of forage for animals. *Cuscuta* is highly associated with lucerne can reduce the quantity and quality of green fodder. Farmers of Gujarat are facing the problem of *Cuscuta* in seed production programme of lucerne. Mainly the infestation of *Cuscuta* occurred in the field conditions through lucerne seeds which can reduce the quality of lucerne seeds also. *Cuscuta* seeds germinate near the soil surface at 10 days after sowing of lucerne and send up slender which rotates slowly until it touches the stem or leaf. On a host plant, the *Cuscuta* stem immediately forms hustoria and totally survives on host plant. Management of *Cuscuta* is serious problem in lucerne hence, an experiment was planned to study the management of *Cuscuta* in lucerne at AICRP-WM farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi* season of the year 2020-21 on loamy sand soil in collaboration with Main Forage Research Station, AAU, Anand. The experiment consisted of eight different herbicides compared with weedy check, *viz.*, T_1: Pendimethalin 38.7% CS680 g/ha PE, T_2 : Pendimethalin 38.7% CS 680 g/ha at 10 DAS,T_3: Pendimethalin 30% + imazethapyr 2% EC (PM) 640 g/ha PE, T_4: Pendimethalin 30% + imazethapyr 2% EC (PM) 800 g/ha PE, T_5 : Imazethapyr10% SL 50 g/ha PoE, T_6: Imazethapyr 35% + imazamox 35% WG (PM) 70 g/ha PE, T_7 : Fluazifop-p-butyl 11.1% + fomesafen 11.1% SL (PM) 250 g/ha PoE, T_8 : Propaquizafop 2.5% + imazethapyr 3.75% ME(PM) 125 g/ha PoE and T_9 : Weedy check were tested under randomized block design with three replications. Before sowing of lucerne, *Cuscuta* seeds were mixed with lucerne seed and performed line sowing keeping the distance of 30 cm between rows.Results indicated that application of pendimethalin 38.7% CS 680 g/ha at 10 DAS, pendimethalin 30%+imazethapyr 2% EC 640 g/ha PE and pendimethalin 30%+imazethapyr 2% EC 800 g/ha PE was found effective and no germination of *Cuscuta* was noticed but pre-emergence application of pendimethalin 30%+imazethapyr 2% EC at both doses was found phytotoxic to the lucerne and affected the germination of lucerne. Further, fluazifop-p-butyl + fomesafen 250 g/ha PoE was also found phytotoxic to lucerne crop and showed burning effect on leaves of lucerne. Among all the herbicidal treatment, significantly higher green fodder yield (22.8 t/ha) at 75 DAS was recorded in application of pendimethalin 38.7% CS 680 g/ha at 10 DAS.

Effect of post-emergence herbicides on weed growth and yield of Japanese mentha

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The experimental study entitled "Bio-efficacy of Bentazone 48 per cent SL against weeds in Japanese mentha (*Mentha arvensis* L.)" was conducted at Agricultural Research Farm of Banaras Hindu University, Varanasi, India, during the Zaid season of 2021. The primary objectives of the experiment were to study the effect of different herbicidal weed management practices on weed dynamics, find out the best herbicidal weed management practice for growth and yield and work out the economics of treatments. The experiment was laid out in Randomized Block Design and was replicated three times. The experiment consisted of 9 treatments with four doses of Bentazone 48% SL, 2,4-D 38% EC, Penoxsulam + Cyhalofop 60% OD, MCPA 40% SL, and hand weeding and weedy check. All the herbicide treatments were applied as post-emergence (20 days after sowing), and the variety was "Kosi".Among the herbicidal treatments, Bentazone 48% SL 920 ml/ha recorded significantly lower weed dry matter accumulation in broad-leaved weeds, whereas herbicides did not much control grassy weeds. All crop growth parameters like number of branches, and number of leaves were recorded higher under the application of Bentazone 48% SL 920 ml/ha followed by Bentazone 48% SL 799 ml/ha. Maximum essential oil content was obtained in hand weeding (at 30 and 60 days after application) and Bentazone 48% SL 920 ml/ha (0.82%) followed by Bentazone 48% SL 799 mL/ha (0.81%).The maximum essential oil yield was obtained in hand weeding (138.66 kg/ha) followed by Bentazone 48% SL 799 mL/ha (132.62 kg/ha). The highest weed index was recorded in weedy check (66.91) followed by penoxsulam + cyhalofop 60% OD 135 mL/ha (64.49) whereas lowest weed index was recorded in Bentazone 48% SL 920 ml/ha(7.25).Leaf Stem ratio and physical and chemical properties of essential oil didn't show significant differences. The maximum value of menthol content was obtained in hand weeding (80.62%) followed by Bentazone 48% SL 799 ml/ha (80.49%).Among the various herbicidal treatments, post-emergence application of Bentazone 48% SL 799 ml/ha recorded highest net returns(3.34 times higher than the weedy check) and B: C ratio followed by post-emergence application of Bentazone 48% SL 920 ml/ha. The benefit-cost ratio (B:C) was highest under Bentazone 48% SL 799 mL/ha (2.89) followed by Bentazone 48% SL 920 ml/ha (2.82). Based on the present study, post-emergence Bentazone 48% SL 920 and 799 ml/ha as post-emergence are suggested against bradleaf weeds in Mentha under Varanasi's agro-climatic conditions.

Changing significance of Italian Ryegrass (*Lolium perenne* ssp. *multiflorum*) in global cropping systems

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The genus *Lolium* comprises of eight species, among which Italian (*Lolium perenne* ssp. *multiflorum*), perennial (*L. perenne* ssp. *perenne*), and rigid ryegrass (*L. rigidum)* have been historically cultivated all over the world as an important pasture and turf species. In the last 200 years, *Lolium* species have spread from their native places in Europe, temperate Asia, and North Africa to southern parts of Africa, Australia, New Zealand, and North and South America, and unfortunately have become a significant weed problem in several parts of the world in past few decades. Among the species, Italian ryegrass which is a C_3 and was cultivated in Italy at the end of 12^{th} century as a popular forage and turf species is today a significant weed in winter cereals and row crops worldwide. In fields infested with Italian ryegrass, yield loss up to 92% in wheat and 100% in onion have been reported. Owing to its obligate allogamous nature due to self-incompatibility, Italian ryegrass hybridize with other *Lolium* and related species, for example, Festuca, and can develop a species complex in natural landscape. Its broad genetic diversity, wide phenotypic plasticity, and high fecundity combined with huge seed shattering have contributed to its aggressive invasiveness. Because of the presence of variable degree of seed dormancy and multiple cycles of dormancy release in field conditions, Italian ryegrass can survive different management practices by undergoing localized speciation or developing new biotypes. High adaptive potential and survival under multiple adversities including herbicides have contributed to the evolution and spread of herbicide resistance –both multiple and cross resistance– in this species. With limited herbicide options currently available to control Italian ryegrass, integrated management strategy that involves mechanical tool such as harvest weed seed control is a need of the hour. Recent introduction of Italian ryegrass in north India as a potential forage crop because of its luxurious growth and high protein content has drawn wide interest. However, given its natural adaptability and expansion to wide geographical areas including the warmer subtropical climate and rapid reversal to feral followed by weedy biotypes, careful monitoring is absolutely required to avoid future weed pandemic in Indian cropping systems. As accurate taxonomic identification and extensive knowledge on biology and ecology are key to manage a species at local level, Italian ryegrass biology and ecology must be reviewed periodically for its localized containment across global cropping systems, including that in India.

Integrated weed management in cumin

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An experiment was conducted at S.D.A.U, Sardarkrushinagar, Gujarat during three consecutive *Rabi* seasons of the years 2017-18, 2018-19 and 2019-20. The experiment consisted of ten treatments (T_1: Pendimethalin 1.0 kg/ha as PE, T_2: Oxadiargyl 100 g/ha as early PoE, T_3: Metribuzin 1.0 kg/ ha asearly PoE, T_4: Pendimethalin 1.0 kg/ha as PE*fb* 1 HW at 35-40 DAS, T_5: Oxadiargyl 100 g/ha as PE *fb* 1 HW at 35-40 DAS, T_6: Metribuzin 1.0 kg/ha as PE*fb* 1 HW at 35-40 DAS, T_7: Tank mixture ofOxadiargyl50 g/ha + Oxyfluorfen 30 g/ha as PoE at 20-25 DAS, T_8: Weed free (20 and 40 DAS), T_9: Unweed control, T_{10}: Paraquate 0.5 kg/ha as early PoE). A randomized block design with three replications was used. In cumin crop, significantly higher plant height at 60 DAS, plant height at harvest, number of branches per plant, number of umbels per plant, test weight, seed yield and straw yield were recorded under the treatment T_8(Weed free) in pooled results, which remained statistically at par with the treatment T_7 (Tank mixture of oxadiargyl 50 g/ha + oxyfluorfem 30g/ha as PoE at 20-25 DAS) in number of umbels per plant and seed yield; moreover it was at par with oxadiargyl 100 g/ha as PE *fb* 1 HW at 35-40 DAS in number of umbels per plant. Significantly lowest weed population at 30, 60 DAS, at harvest and weed dry matter at harvest were recorded under weed free treatment (20 and 40 DAS) during pooled over year. Treatment T_8 (weed free) recorded maximum weed control efficiency and minimum in weed index as well as unweed control was observed minimum weed control efficiency and maximum weed index. The economic analysis revealed that treatment T_8 (Weed free: 20 and 40 DAS) recorded significantly higher net returns of ¹ 94,560/ha with 5.33 B:C ratio. Among weed management treatment T_7 (Tank mixture of Oxadiargyl 50 g/ha + oxyfluorfem 30g/ha as PoE at 20-25 DAS) attained maximum net income of ¹ 90, 475/ha with B: C ratio 5.04.

Weed management in summer pearl millet in South Gujarat

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Pearl millet [*Pennisetum glaucum* (L.) R.Br.] is one of the important food grain crops which ranks 5th in area. The share of pearl millet in total food grain production is nearly 10%. Among various agronomical practices, weed management is one of the most important which affect the crop growth and yield, but generally this is neglected by farmers. Weeds are one of the major barriers responsible for low productivity of pearl millet, because weeds compete with the crop for moisture, nutrients, space and light and reduces on an average 55% pearl millet production due to weed infestation. Weeds being naturally hardy and competitive, results in poor yield of crop. The weed flora varies with field to field and, the appropriate weed management practices need to be adopted by considering soil and climatic conditions for better yield and effective weed management in summer season. A field experiment was carried out at Navsari Agricultural University, Navsari on integrated weed management in summer pearl millet with fourteen weed management treatments replicated four times in randomized block design. Pre-emergence application (PE) of atrazine 0.50 kg/ha followed by (*fb*) intercultivation (IC) and hand weeding (HW) at 25 days after seeding (DAS) and pendimethalin 0.75 kg/ha PE *fb* IC and HW at 25 DAS proved better efficient with higher weed control efficiency and lower weed index than rest of the treatments. Atrazine 0.50 kg/ha PE *fb* IC and HW at 25 DAS recorded the higher grain and straw yields. Sedges weed were effectively controlled by only mechanical weed control. This was ultimately reflected in lowest weed biomass with weed free condition and also least weed density in the same treatment. The maximum net returns and B:C ratio were accrued recorded withweed free condition which was closely followed by atrazine 0.50 kg/ha PE- *fb* + interculturing and hand weeding at 25 DAS. Application of atrazine 0.50 kg/ha as PE *fb* interculturing and hand weeding at 25 days after sowing is more economical and profitable to reduce early crop-weed competition and economical management of weeds in summer pearl millet crop under South Gujarat conditions.

Impact of mulching and weed control treatments on productivity of cotton

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Weed infestation in cotton has been reported to offer severe competition and causing yield reduction to a large extent. Weeding via cultural practices is time consuming, tedious and expensive due to long duration of cotton crop and regular monsoon rains. Chemical weed control in cotton has been successfully utilized in the recent past. However, continuous use of similar herbicides leads to resistance in weeds against herbicides and when sprayed to the field herbicides not only suppress the weeds that are targeted but they can leave undesirable residues in the soil that are hazardous to environment. Therefore, a study was performed at cotton research area, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) during *Kharif* and *Rabi* season of 2020, 2021 and 2020-21, 2021-22, respectively. The experiment was laid out in factorial randomized block design with two mulching levels (no mulch and mulching with rice straw 7.5 t/ha) and seven weed management levels: weedy check, weed free, pre-emergence application (PE) of pendimethalin 1.5 kg/ha followed by (*fb*) two hoeing at 45 and 90 days after seeding (DAS), hoeing twice at 30 and 60 DAS *fb* post-emergence application (PoE) of quizalofop-p-ethyl 62.5 g/ha at 90 DAS, hoeing twice at 30 and 60 DAS *fb* propquizafop-p-ethyl 50 g/ha PoE at 90 DAS, pendimethalin PE 1.5 kg/ha *fb* one hoeing 45 DAS *fb* paraquat 0.5% (protected spray) at 90 DAS and pendimethalin PE 1.5 kg/ha *fb* one hoeing 45 DAS *fb* glyphosate 1% (protected spray) at 90 DAS, with three replications. Mulching with rice straw7.5 t/ha resulted in significantly higher seed cotton yield (3.19 and 3.08 t/ha in 2020 and 2021, respectively) and better weed control in comparison to no mulch (2.99 and 3.19 t/ha in 2020 and 2021, respectively). Among weed management treatments tested apart from weed free, significantly lowest seed cotton yield (1.84 and 1.76 t/ha) was recorded in weedy check in comparison to other treatments while all other treatments were statistically at par with each other during both years of crop experimentation. Highest weed control efficiency at harvest (72.2 and 72.3%) obtained with pendimethalin PE 1.5 kg/ha *fb* one hoeing at 45 DAS *fb* glyphosate 1% (protected spray) at 90 DAS. Next best treatment was pendimethalin 1.5 kg/ha PE fb hoeing twice at 45 and 90 DAS (54.9 and 54.4%) during *Kharif* 2020 and *Kharif* 2021, respectively. Herbicide efficiency index (7.13 and 7.31) achieved with pendimethalin 1.5 kg/ha PE *fb* one hoeing at 45 DAS *fb* glyphosate 1% (protected spray) at 90 DAS during both years of crop experimentation.

Evaluation of post-emergence herbicide in kodo millet (*Paspalum scrobiculatum* (L.) P. Beauv)

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Among the minor millets, kodo millet is gaining popularity due to health consciousness as it is rich in nutrients. The initial growth of the millets is very slow, which paves favourable conditions for weed multiplication to occur, thus crop suffers heavy weed infestation and gradually becomes a serious limitation for low production. Effective control of weeds during critical crop growth period is vital. Considering the present labour scarcity and drudgery, the use of herbicide was found to be an efficient weed management strategy for kodo millet cultivation. Studies herbicides for weed control in kodo millet are scanty. Thus, a field study was exclusively conducted consecutively for two years from 2019 to 2021 to screen the right post-emergence herbicide to control weeds in kodo millet. The experiment was laid out in a randomized block design comprising 16 treatments and 3 replications at AICRP- Weed Management, Bengaluru. The experiment consisted of seven post-emergence herbicides (bispyribac- sodium, cyhalofop-butyl, fenoxaprop-ethyl, metsulfuron-methyl + chlorimuron-ethyl, tembotrione, 2, 4-D sodium salt and ethoxysulfuron) each at two different doses which were compared with hand weeding twice at 20 and 40 days after seeding(DAS) and weedy check. From the preliminary screening of the post-emergence herbicides, metsulfuron-methyl (10%) + chlorimuron-ethyl (10%) -20 WP (2+2) 4 g/ha at 20-25 DAS recorded significantly higher seed yield (1.33 t/ha) followed by 2, 4 D sodium salt 750 g/ha (1.11 t/ha) compared to weedy check (0.69 t/ha). Highest BC ratio (2.13) was obtained in metsulfuron-methyl + chlorimuron-ethyl 4 g/ha at 20-25 DAS and 2, 4 D sodium salt 750 g/ha (1.79) compared to weedy check treatment (1.13). Similar trend was observed in weed index (%) where metsulfuron-methyl + chlorimuron-ethyl 4 g//ha at 20-25 DAS and 2, 4 D sodium salt 750 g/ha recorded lower weed index (1% and 18%, respectively) compared to weedy check (49%). Regarding economics, the higher net return (₹ 28208 and 19547) and marginal return (₹ 25600 and 16800) were recorded with post-emergence herbicides metsulfuron-methyl + chlorimuron-ethyl 4 g/ha at 20-25 DAS and 2, 4 D sodium salt 750 g/ha, respectively compared to weedy check. On screening various herbicides, it can be concluded that application of post-emergence herbicides metsulfuron-methyl + chlorimuron-ethyl 4 g/ha at 20-25 DAS and 2, 4 D sodium salt 750 g/ha holds immense potentiality in controlling weeds effectively in kodo millet and also saving in weeding cost from ₹4784 to 4923/ha.

Weed management in *Bt.* cotton through sequential and tank mix application of herbicides

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Cotton has a pride place among the cultivated plants that satisfy the material need of man which is prime need of life. Among many constraints for low cotton productivity, the most troublesome one is competition from weeds particularly during early stages of crop growth. Further, there is need to go for combination of herbicides or herbicide mixtures for broad spectrum weed control especially in long duration crop like cotton. To find out efficacy of sequential and tank mix application of herbicides for managing weeds in *Bt.* cotton, a field study was carried out at the farm of AICRP on Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat in loamy sand soil during two consecutive *Kharif* season of the year 2019 and 2020. Total ten weed management practices comprised of various sequential as well as tank mix application of herbicides and mechanical methods were compared with weedy check in the experiment under Randomized Block Design (RBD) with four replications. Significantly lower total weed density (14.73 no./m^2) and total weed biomass (33.72 g/m^2) with higher growth and yield attributing characters, *viz.* plant height (205.44 cm), number of monopodial (4.40) and sympodial branches (25.35) per plant, seed index (9.64 g), number of bolls per plant (59.50) and seed cotton yield (3.24 t/ha) were registered under pre-emergence application (PE) of pendimethalin 500 g/ha + oxyfluorfen 50 g/ha (tank-mix) *fb* post-emergence application (PoE) of pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha (tank- mix) applied at 30 days after seeding (DAS) which remained at par with treatment of oxyfluorfen 100 g/ha as PE *fb* glufosinate ammonium 375 g/ha as PoE (directed spray) and interculturing (IC) *fb* hand weeding (HW) at 20, 40 and 60 DAS. Weedy check resulted in 71.01% yield reduction in *Bt.* cotton due to presence of weeds. Altogether fourteen weed species were observed in experimental area. Application of pendimethalin PE gave poor control of *Commelina benghalensis* L. among monocot weeds and *Digera arvensis* L. among dicot weeds. Post-emergence application of glufosinate ammonium or pyrithiobac-sodium + quizalofop-ethyl (tank mix) can also be used as directed spray as an alternate herbicide to glyphosate or paraquat for managing weeds in cotton. With regards to phytotoxicity of applied herbicides on crop, none of herbicide caused any injury except oxyfluorfen which showed slight necrosis and epinasty symptoms (10 to 20%) at initial stage on cotton which was recovered in due course of time, but early cotton phytotoxicity has no significant long-term effect on growth, development or yield of *Bt* cotton. Further, pendimethalin 500 g/ha + oxyfluorfen 50 g/ha PE (tank-mix) *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha PoE (tank-mix), oxyfluorfen 100 g/ha PE *fb* glufosinate ammonium 375 g/ha PoE directed spray and IC + HW at 20, 40 and 60 DAS recorded higher net realization of Rs.178365/ha, Rs.166760/ha and ₹ 163515/ha, respectively with benefit cost ratio of 3.32, 3.26 and 2.85, respectively.

Integrated weed management in fodder oat

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A field trial was conducted during the *Rabi* season of 2017-18 to 2019-20 at Instructional Farm, Department of Agronomy, N. M. College of Agriculture, Navsari Agricultural University, Navsari, to study the integrated weed management in fodder oat. The soil of the experimental field was clayey in texture, low in organic carbon content and low in available nitrogen, medium in available phosphorus, high in available potassium and slightly alkaline in reaction. The climate of this region is typically tropical monsoon type characterized by three well-defined seasons, *viz.*, warm and humid monsoon with heavy rainfall, moderately cold winter and fairly hot and humid summer. The experiment consists of two sowing methods, S_1: line sowing and S_2: cross sowing, five weed management treatments, W_1: unweeded control, W_2: weed-free [hand weeding (HW) twice at 20 and 40 days after seeding (DAS)], W_3: pendimethalin 1 kg/ha pre-emergence application (PE), W_4: 2,4-D amine salt 0. 5 kg/ha as post-emergence application (PoE) at 30 DAS and $W_{5:\,m}$etsulfuron-methyl 4 g/ha PoE 30 DAS. A total ten treatments combination were laid out in factorial randomized block design (FRBD) with three replications. Different weed management practices exerted their significant influence in numbers of monocot, dicot, total weeds population and weed biomass in pooled result. Significantly lowest weeds (monocot and dicot) were reported in weed free treatments but, there was no significant difference found in sedges. The interaction effect (S X W) was found to be significant on total weed and biomass in pooled results, where in treatment combination cross sowingwith weed-free (HW twice at 20 and 40 DAS) recorded significantly lowest total weed density and biomass. All the herbicidal weed management treatments recorded significant effect on plant height, green and dry fodder yield of oat than unweeded control and weed-free treatment. Pendimethalin 1 kg/ha PE recorded substantially higher plant height, green fodder and dry fodder yield, which was at par with metsulfuron-methyl 4 g/ha PoE 30 DAS and 2,4-D amine salt 0. 5 kg/ha PoE at 30 DAS. Based on the three years experimentation result, higher yield with net monetary returns recorded by cross sowing method. In the case of weed management, pendimethalin 1 kg/ha PE produced a higher yield with net monetary return as followed by metsulfuron-methyl 4 g/ha PoE 30 DAS or 2,4-D amine salt 0. 5 kg/ha PoE at 30 DAS.

Comparative study of different weed control measures in cumin

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India has an old history of cultivation of spices and takes benefit of being the largest producer, exporter and consumer of spices in the world. Cumin (*Cuminum cyminum* L.) locally known as '*zeera*' is an important spice commodity cultivated in a large area in arid and semi-arid regions of Rajasthan and Gujarat which have favourable soil and climatic conditions for its cultivation. India is the largest producer and consumer of cumin. The major growing areas in Rajasthan are Barmer, Jalore, Nagaur, Pali, Ajmer, Bhilwara, Tonk, Jodhpur, Jaisalmer, Sirohi, Sikar and Bikaner. The cumin crop is favoured by farmers due to higher profit with less input cost compared to other *Rabi* crops. Cumin is a short stature crop with slow growth at initial stage, which makes it incapable to offer competition with weeds. The dominant weed flora in cumin field consisted of *Chenopodium album, Chenopodium murale, Cynodon dactylon, Cyperus rotundus, Melilotus alba, Argemone mexcicana, Asphodelus tenuifolius, Plantago pumila, Rumex dentatus and Launea asplenifolia*. Weeds take a heavy toll of applied nutrients. They also discourage the plant growth by some hidden effects known as teletoxy. This situation is aggravated by the broadcasting method of sowing. Research studies have revealed a loss of 80-90% in the seed yield of cumin due to weed infestation depending upon the intensity and type of weed flora. Hence, there is strong chance of crop failure if the weed problem is not managed properly. Manual removal of weeds, generally followed by cumin growers, is tedious, labour consuming and expensive. Moreover, there is shortage of manpower during early growth stage and therefore, complete weeding is not possible. This situation creates wide scope for use of pre- and post-emergence herbicides in combination with hand weeding for effective weed management practices. An experiment was conducted to find out the effective and economically viable weed management practices for obtaining higher yield of cumin. The treatments were comprised of different combinations of pendimethalin, oxyfluorfen and oxadiargyl herbicides at different rates alonwith hand weeding. Weed- free treatment recorded significant maximum growth and yield attributes of cumin followed by oxadiargyl at 0.06 kg/ ha pre-emergence application (PE) followed by (*fb*) hand weeding twice at 40 and 60 days after sowing (DAS). Similarly, significantly maximum seed yield (595 kg/ha), straw yield (900 kg/ha) and harvest index (39.7%) was observed with oxadiargyl at 0.06 kg/ha PE *fb* hand weeding twice at 40 and 60 DAS. Maximum weed density was observed in weedy check, which was followed by hand weeding (40 DAS) at all the growth stages of cumin. It may be concluded that oxadiargyl at 0.06 kg/ ha PE *fb* hand weeding twice at 40 and 60 DAS may be used for higher yield of cumin.

Weed growth as influenced by method of planting, intercrops and fertilizer management in ELS cotton

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Field experiment was conducted at Eastern Block Farm, Department of Agronomy, TNAU, Coimbatore during summer 2019 to find out weed density, weed biomass and weed smothering efficiency of cotton under different methods of crop establishment, different intercrops and nutrient management in Extra Long Staple cotton (ELS). The experiment was laid out in randomized block design with three replications. The treatments consisted of: cotton establishment techniques, suitable intercrops and fertilizer management, *viz.* T_1 : transplanting cotton + greengram + 75% Recommended Dose of Fertilizer (RDF), T_2 : transplanting cotton + blackgram + 75% RDF, T_3 : transplanting cotton + onion + 75% RDF, T_4 : transplanting cotton + greengram + 100% RDF, T_5 : transplanting cotton + blackgram + 100% RDF, T_6 : transplanting cotton + onion + 100% RDF, T_7 : transplanting cotton + greengram + 125% RDF, T_8 : transplanting cotton + blackgram + 125% RDF, T_9 : transplanting cotton + onion + 125% RDF, T_{10} : transplanting cotton + 100% RDF, T_{11} : dDirect seeding + rRecommended package of practices. The weed density and weed biomass was higher in direct-seeded cotton followed by transplanting cotton with 100% RDF applied which are non-intercrop treatment plots. The reduction in weed density was observed in cotton transplanting intercropped with greengram + 75% RDF application (78.87 no./m^2) at 20 DAS and 50.76 no./m^2 at 40 DAS and highest weed density was recorded in direct-seeded cotton (205.36 no./m^2) at 20 DAS and (195.57 no./m^2) at 40 DAS. The weed biomass was highest in direct-seeded cotton 120.80 g/m^2 at 20 DAS and 128.90 g/m^2 at 40 DAS and lowest weed biomass was recorded in cotton seedling transplanting intercropped with greengram along with 75% RDF was 63.51 g/m^2 at 20 DAS and 52.20 g/m^2 at 40 DAS. In terms of weed smothering efficiency (WSE), cotton transplanting intercropped with greengram + 125% RDF is 68.99% at 20 DAS and 77.95% at 40 DAS followed by cotton transplanting intercropped with blackgram + 125% RDF is 64.30% at 20 DAS and 72.46% at 40 DAS and lowest WSE was recorded in cotton transplanting + 100% RDF is 26.32% at 20 DAS and 31.17% at 40 DAS. Cotton intercropping with greengram, blackgram and onion plays prominent role in controlling weeds compared to non-intercropping plots. Hence, it was concluded that, transplanted cotton intercropped with greengram + 125% RDF showed better performance by keeping weeds in control.

Effect of weed control measures on weed growth and yield of dual-purpose sorghum

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A field experiment was carried out at Agricultural College and Research Institute, Killikulam, Tamil Nadu to investigate the effect of different weed management practices on weed growth and yield response of dual-purpose sorghum variety K 12 (*Sorghum bicolor* L.) during *Rabi* season 2019-2020. The experiment was laid out with a Randomized Block Design with twelve treatments and three replications. The treatments include pre-emergence application (PE) of atrazine at 0.5 kg/ha and pendimethalin at 0.5 kg/ha, each in combination with four different practices, *viz.* post-emergence application (PoE) of 2, 4-D at 0.5 kg/ha, metsulfuron-methyl at 6 g/ha PoE, hand weeding twice at 40 days after sowing (DAS) and mechanical weeding at 40 DAS. Also, mechanical weeding twice at 20 and 40 DAS, hand weeding twice at 20 and 40 DAS, weed-free check and unweeded control were included in the treatments. Observations on weed biomass, weed density, weed index, weed control efficiency and the grain yield and stover yield of the dual-purpose sorghum crop were recorded. The application of atrazine at 0.5 kg/ha PE combined with one-hand weeding at 40 DAS recorded significantly lower weed density (5.42 no./m^2) and lower weed biomass (3.06 g/m^2), this was on par with weed-free check 0.71 no./m^2 and 0.71 g/m^2 respectively. While the higher weed density (24.30 no./m^2) and higher weed biomass (17.12 g/m^2) were recorded in unweeded control. Lower weed index was recorded in weed-free check (0.0%) with higher weed control efficiency (100%) followed by atrazine at 0.5 kg/ha PE + one hand weeding at 40 DAS which recorded a weed index of 5.8% with higher weed control efficiency of 97%. A higher weed index (60.6%) was recorded in the unweeded check with lower weed control efficiency (0.0%). The grain yield and stover yield of dual-purpose sorghum were higher under weed-free check yielding 4.2 t/ha and 12.0 t/ha respectively. It was on par with atrazine at 0.5 kg/ha PE along with hand weeding once at 40 DAS recorded at about 4.0 t/ha and 11.5 t/ha, respectively. The lowest grain and stover yield were recorded under unweeded control (1.7 t/ha and 5.4 t/ha respectively). It was concluded that the competition offered by the weeds to the crop was minimum with the use of atrazine PE along with hand weeding once at 40 DAS which performed better in managing the weeds and producing a higher yield of dual-purpose sorghum.

Bio-efficacy and phyto-toxicity of clethodim on cotton

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India is the leading country in terms of area under cotton in the world. Gujarat, Maharashtra and Telangana are the major cotton growing states contributing around 70% of the area and 67% of cotton production in India. Cotton is the main *Kharif* crop of Gujarat and covers around 27.61 lakh ha area, which is next to Maharashtra in India. Losses in seed cotton yield due to presence of weeds is maximum. Weeds not only compete with the crop for nutrients, light, moisture, space and energy but, also harbor insects and disease organism thus, reducing the growth and yield of cotton due to weed competition. Cotton generally needs weed management in early stages of growth. Field experiment was conducted to assess the bio-efficacy and phyto-toxicity of clethodim on cotton, at College of Agriculture, Navsari Agricultural University, Bharuch during *Kharif* season of 2014-15 and 2015-16 under rainfed condition. Total nine treatments were tested with six treatments that consisted of level of clethodim, *viz.*, 60, 90, 120, 150, 240 and 300 g/ha along with 0.5% Amigo (Surfactant) and three other treatments, *viz.* quizalofop-ethyl 50 g/ha, weed -free check and weedy check were evaluated with three replications in a randomized block design. The soil of the experimental field was clayey in texture, low, medium and high in available nitrogen (209 kg /ha), phosphorus (40.6 kg /ha) and potassium (384 kg /ha), respectively. Weekly mean maximum and minimum temperature varied from 33.4 °C to 39.4°Cand 13.8 °C to 27.1°C, respectively. The mean morning relative humidity (7:00 a. m.) ranged from 80.7 to 89.0% and 38.6 to 71.2% at evening (2:30 p. m.). Mean bright sunshine hours were available in the range of 7.7 to 10.8 hrs/day during the course of investigation (11th to 23rd standard week). Major weed flora, *viz. Cloris infata, Brachiara* spp.*, Dinebra retroflexa, Eragrostis major* among monocots; *Digera arvensis, Portulaca oleracea, Euphorbia hirta* among dicots and *Cyperus rotundus* only sedges were recorded during investigation. Total weed density and biomass significantly reduced under weed-free condition and herbicidal treated plots, however, clethodim 300 g/ha + 0.5% Amigo was more effective among the herbicides. Moreover, clethodim 60 to 300 g/ha or quizalofop-ethyl 50 g/ha were not effective on dicot and sedges weeds. Further, highest weed control efficiency and lowest weed index was observed in weed-free check, closely followed by clethodim 240 or 300 g/ha + 0.5% Amigo. Plant height, no. of monopodial and sympodial branches/plant, no. of ball/ plant, seed cotton yield was significantly higher under weed free and were at par with clethodim either applied at 240 or at 300 g/ha +0.5% Amigo. Clethodim 240 g/ha +0.5% Amigo (surfactant) was found promising by producing higher seed cotton yield as well effectively control monocot weeds.

Herbicidal impact on density of *Cuscuta campestris Yunck.* emerged in berseem fodder crop

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Gwalior is located in the central part of Madhya Pradesh at 23^0 10' N latitude, 79^0 54' E longitude and an altitude of 411.98 m from sea level. The mean temperature varies between 2^0C in December-January to 46^0C in May-June. The average rainfall is 750 mm which is mostly received in between July to September. Soil of the experimental field is sandy loam in texture (sand 58.4, silt 14.6 and clay 22.0%) low in available nitrogen (237.0 kg/ha), medium in phosphorus (19.7 kg/ha) and potassium (277.1 kg/ha) with pH 7.8. Electrical conductivity of soil was 0.25 dS/m^1 having 0.30% soil organic carbon. Berseem (*Trifolium alexandrinum* L.) is one of the most important *Rabi* season leguminous fodder crop in India and is widely cultivated because of multi cut and known as king of the fodder crop. Field experiment was conducted at the research farm of RVSKVV Gwalior during *Rabi* 2018-19 and 2019-20 to investigate the interference of *Cuscuta campestris* densities and the efficacy of herbicides for its control in berseem. *C. campestris* well known as a dodder has hard-coated seed that can remain dormant in the soil for more than 20 years. It is an annual stem holoparasitic grows only by penetrating tissues of host plants to obtain water and nutrients. It is a serious problem of berseem. Eight treatments consisting of pendimethalin 1000 g/ha (PE), pendimethalin 1000 g/ha as early post-emergence application (EPoE) at 10 days after seeding (DAS), oxyfluorfen 250 g/ha pre-emergence application (PE), imazethapyr 40 g/ha after first cut, imazethapyr 40 g/ha after last cut, imazethapyr 40 g/ha after first cut + 40 g/ha after last cut, *Cuscuta* fee and control plot (no herbicide application) were laid out in RBD with three replications. The *Cuscuta* infested seed was sown in rows with 20 cm space. Number of *Cuscuta* emerged/m^2 was recorded at 30, 60 90 and at120 DAS. The first cutting of fodder was done at 60 DAS and subsequent 2 cuttings were done at 30 days intervals. The post-emergence application of imazethapyr 40 g/ha after first cut at 60 days after sowing (DAS) was found to be very effective in controlling the *Cuscuta* causing 43% and 16% higher fodder and seed yield respectively with 43.6% higher profitability. The next best was imazethapyr 40 g/ha after first cut + 40 g/ha after last cut. The pre-emergence application of pendimethalin and oxyfluorfen caused phytotoxicity to berseem due to the higher dose of both herbicides and reduced the fodder and seed yield drastically.

Evaluation of suitable pre-emergence herbicide for sunnhemp seed production

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Sunnhemp (*Crotalaria juncea*) is an important green manure leguminous crop adapted to tropical and subtropical regions. India is the largest country having 10300 ha area under sunnhemp cultivation with the production of 41500 bales and average productivity of 728 kg/ha. Apart from green manure, it is used as cover crop due to its fast-growing nature. Weed management is not much important for cultivation of sunnhemp as green manure crop. It is very essential to control the weeds in sunnhemp seed production field to produce quality seed material without admixture of weed seeds. Proper weed management practices help to reduce the development of weed seed bank in the field and reduce the weed infestation in succeeding crop. Weed competition is one of the major biotic constraints in reducing the productivity of sunnhemp under irrigated conditions. Cultural method of weed management effectively control the weeds, but it also poses some limitations. Non-availability of labour, higher rate of wages and unfavourable soil and climatic conditions are the major problems in cultural weed control methods. Hence, the weed management with herbicide usage is gaining importance. The application of herbicides significantly controls the weeds during the early period of the crop growth. The study was directed to evaluation of suitable pre-emergence herbicide for sunnhemp seed production. A field experiment was conducted at Eastern Block farm of Tamil Nadu Agricultural University, Coimbatore in February, 2018. The experiment consisted of six treatments, *viz*. pre-emrgence application (PE) of pendimethalin at 1.0 kg/ha followed by (*fb*) hand weeding, pendimethalin at 0.75 kg/h PEa *fb* hand weeding, oxyfluorfen at 0.3 kg/ha PE *fb* hand weeding, oxyfluorfen at 0.4 kg/ha PE *fb* hand weeding, weed free check [hand weeing twice at 20 and 40 days after seeding (DAS)] and unweeded control with four replications and laid out in randomized block design. The pre-emergence herbicides were applied at 3 DAS and hand weeding was given at 30 DAS. The pendimethalin at 1.0 kg/ha PE *fb* one hand weeding at 30 DAS recorded lesser weed density (16 number/m^2) and higher weed control efficiency (77%). The application of herbicides did not affect the sunnhemp germination and establishment. The highest plant height (151 cm) and dry matter production (1.7 t/ha) were recorded with pendimethalin at 1.0 kg/ha PE *fb* one hand weeding at 30 DAS. It could be concluded that pendimethalin at 1.0 kg/ha PE *fb* hand weeding at 30 DAS was effective in weed control and it was suitable for quality seed production in sunnhemp.

Chemical weed management practices on growth and yield of pearl millet

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An experiment was conducted during *Kharif* 2020 at College of Agriculture, Dhule. Experiment consisted of nine treatments laid out in randomized block design with three replications. Different weed control treatments had significantly influenced the weed population, growth and yield of Pearl millet. Pearl millet growth characters, *viz.* plant height (cm), number of leaves per plant, leaf area per plant (dm^2), number of tillers per plant, number of effective tillers per plant, dry matter per plant (g), yield contributing characters like earhead length per plant (cm), earhead girth per plant (cm), weight of earhead per plant (g), grain weight per earhead (g) and test weight (g) were significantly higher with weed free t than with the rest of weed control treatments tested. They were lower in weedy check. In respect of growth characters and yield contributing characters, pre-emergence application (PE) of pendimethalin 750 g/ha followed by (*fb*) post-emergence application of 2, 4-D (Na Salt) 0.5 kg/ha at 30 DAS was next best treatment and was significantly superior over other chemical weed management treatments but it was at par with pendimethalin750 g/ha PE *fb* 2,4-D (Dimethyl-amine) 0.5 kg/ha PoE at 30 DAS. The grain and straw yield (kg/ ha) of pearl millet was found to be significantly higher (2.9 and 5.3 t/ha, respectively) in treatment of weed free. Among the different chemical treatments, pendimethalin750 g/ha PE *fb* 2,4-D (Na Salt) 0.5 kg/ ha at 25-30 DAS PoE recorded significantly maximum grain and straw yield (2.7and 5.1t/ha, respectively) as compared to other treatments of weed control and it was found at par with pendimethalin750 g/ha PE *fb* 2,4-D (Dimethyl- amine) 0.5 kg/ha PoE at 30 DAS (2.5 and 4.1 t/ha, respectively). Among the herbicidal treatments tried in the experiment, application of pre-emergence herbicide followed by post-emergence herbicide treatment was found significantly better than application of post-emergence herbicide only in respect of grain and straw yield of pearl millet, probably be due to better weed management resulting in improvement in all growth and sink parameters which contributed higher yield owing to favourable condition in absorbing soil moisture, nutrient content and sunlight penetration during crop growing period. From the economic point of view pendimethalin 750 g/ha PE *fb* 2,4-D (Na Salt) 0.5 kg/ha PoE at30 DAS and pendimethalin 750 g/ha PE *fb* 2,4-D (Dimethyl-amine) 0.5 kg/ha PoE at 30 DAS were found to be economically viable treatments based on B:C ratio.

Weed management in *Kharif* grain sorghum

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A field experiment was conducted during *Kharif* season,2019-20 in loamy sand soils of Centre for Millets Research, Sardarkrushinagar Dantiwada Agricultural University, Deesa whicht falls under the North Gujarat Agro climatic zone-IV of the state and lies at a latitude of 24.5˚ N and longitude 72˚ E and at an elevation of 136 M above the Mean Sea Level. The centre is located under arid and semi-arid climatic conditions having hot, dry summer (May–June, 45˚C) and moderate winter (December–January, 10˚-12˚C). The farm soil is deep and sandy in texture with pH value of 7.8 -8.0 having poor physical and chemical properties. The objective of the study was to study the effect of weed management in sorghum-on-sorghum productivity. The experiment was conducted by using *Gujarat Juvar 43* in randomized block design with three replications. Ten treatments of weed management were tested, *viz.* T_1 : weedy check, T_2 : weed free (hand weeding (HW) twice at 25 and 50 days after seeding (DAS) followed by (*fb*) one interculture at 50 DAS), T_3 : pre-emergence application (PE) of atrazine 1.5 kg/ha, T_4 : post-emergence application (PoE) of 2,4-D amine 1.0 kg/ha at 20 DAS, T_5 : halosulfuron methyl 100 g/ha PoE at 20 DAS, T_6 : atrazine 1.5 kg PE /ha *fb* 2,4-D amine 1.0 kg ai/ha PoE at 40 DAS, T_7 : atrazine 1.5 kg/ha PE *fb* halosulfuron-methyl 100g/ha PoE at 40 DAS, T_8: atrazine 1.5 kg/ha PE + one HW at 40 DAS, T_9 : 2,4-D amine 1.0 kg/ha PoE at 20 DAS *fb* one HW at 40 DAS and T_{10} : halosulfuron-methyl 100 g/ha PoE at 20 DAS *fb* one HW at 40 DAS. The recommended dose of fertilizer (RDF) of Sorghum in North Gujarat is 80:40:0 NPK kg/ha. In all the treatments recommended dose of P and half dose of nitrogen was applied as a basal. The predominant weeds were: *Phyllanthus niruri, Tridax procumbens*, *Eragrostis major*, *Digitaria sanguinalis*, *Boerhavia diffusa*, *Leucas aspera*, *Amaranthus spinosus*, *Launaea nudicaulis*, *Dactyloctenium aegyptium, Cyperus rotundus and C. iris.* Significantly highest grain (3.44 t/ha) and dry fodder yield (20.17 t/ha) were recorded with T_2 (weed free) which was statistically at par with T_6 [atrazine 1.5 kg/ha PE *fb* 2,4-D amine 1.0 kg/ha PoE at 40 DAS] for grain yield. Higher weed control efficiency was recorded with T_6 [atrazine 1.5 kg ai/ha PE *fb* 2,4-D amine1.0 kg/ha PoE at 40 DAS] (52.84%) while T_8 (atrazine 1.5 kg/ha PE *fb* one hand weeding at 40 DAS) recorded higher weed control efficiency (91.7%) at harvest. Lowest weed index was recorded (17.01%) with T_6. Highest net return (₹ 186206/ ha) was recorded with T_2 [weed free (HW twice at 25 and 50 DAS *fb* one interculture at 50 DAS)] while benefit cost ratio (3.70) was maximum under treatment T_6 (atrazine1.5 kg/ha PE *fb* 2,4-D amine 1.0 kg/ha PoE at 40 DAS).

Efficacy of different herbicides on weed growth, nutrient uptake and yield of foxtail millet

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Foxtail millet (*Setaria italica* L.) is highly drought resistant crop grown under rainfed condition and produces high quality grains than many other cereals under extreme conditions like unfertile soil, intense heat and prolonged drought. Generally, small millets are relatively poor competitors for growth resources than weeds, especially during the early stages of the crop. The critical period of crop-weed competition in finger millet was up to four weeks after sowing, to obtain higher grain yield. Pre-emergence herbicides improve the weed control and production efficiency in major millets due to their bigger seed size and comparatively deeper depth of sowing than small millets. The yield potential of minor millets including foxtail millet has been very low under rainfed areas because of lack of good management practices. Thus, the present study was conducted during *Kharif* season of 2020 at S. V. Agricultural College, Tirupati, Andhra Pradesh to identify the efficacy of different pre-emergence herbicides on weed growth, nutrient uptake and yield of foxtail millet. The data on weed density and biomass were transformed to square root (transformation to normalize their distribution). Weed control efficiency was computed as per the method suggested. The nutrient uptake (kg/ha) by foxtail millet at harvest was estimated following the standard methods. Significantly higher uptake of nitrogen, phosphorus and potassium by foxtail millet at harvest was recorded with hand weeding (HW) twice. Pre-emergence application (PE) of pretilachlor 500 g/ha followed by (*fb*) intercultivation at 20 days after seeding (DAS) resulted in higher nutrients uptake by crop, which was at par with pyrazosulfuron-ethyl 15 g/ha PE *fb* intercultivation and isoproturon 500 g/ha PE *fb* intercultivation. These three weed management practices offered broad-spectrum weed control during the critical period of crop-weed competition of crop growth which lead to increased plant height, and dry matter production and thereby increased uptake of nutrients by crop. Pretilachlor 500 g/ha PE *fb* intercultivation resulted in higher uptake of 63.33, 16.93 and 57.00 kg/ha of nitrogen, phosphorus and potassium, respectively. Lowest weed density and biomass as well as higher WCE including nutrient uptake of foxtail millet were recorded with HW twice at 20 and 40 DAS followed by pretilachlor 500 g/ha PE *fb* intercultivation at 20 DAS. Heavy weed infestation in unweeded check drained nutrient uptake by 45.67, 18.03 and 35.00 kg/ha of nitrogen, phosphorous and potassium, respectively. Hand weeding twice obtained higher grain yield, but benefit-cost ratio was lesser than the best weed management practice *i.e*., pretilachlor 500 g/ha PE *fb* intercultivation at 20 DAS.

Poster 200

Chemical weed management in grain sorghum in labour scarcity

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Sorghum being a narrow-spaced crop faces severe competition of weeds at initial stages. Consistent rains during monsoon season limits the inter-culturing and hand weeding operations in *Kharif* sorghum in South Gujarat. Beside labour scarcity is also a bottleneck for timely weed management, resulting in considerable yield losses. Under these circumstances chemical weed control would be good alternative. Considering this certain pre- and post-emergence herbicides were tested alone and in combinations with cultural methods at field level during 2017 to 2019. The treatment includes weedy check (T_1), weed free (hand weeding (HW) at 25 and 50 days after sowing (DAS) + inter-culturing at 50 DAS) (T_2), atrazine 1.5 kg/ha pre- emergence (PE) (T_3), 2,4-D (amine salt) 1.0 kg/ha post- emergence (PoE) at 20 DAS (T_4), halosulfuron methyl 100 g/ha PoE at 20 DAS (T_5), atrazine 1.5 kg/ha PE *fb* 2,4-D (amine salt) 1.0 kg/ha PoE at 40 DAS (T_6), atrazine 1.5 kg/ha PE *fb* halosulfuron methyl 100 g/ha PoE at 40 DAS (T_7), atrazine 1.5 kg/ha PE *fb* HW at 40 DAS (T_8), 2,4-D (amine salt) 1.0 kg/ha PoE at 20 DAS *fb* HW at 40 DAS (T_9), halosulfuron methyl 100 g/ha PoE at 20 DAS *fb* HW at 40 DAS (T_{10}). The study was conducted at Cotton Research Sub Station, Navsari Agricultural University, Achhalia (21° 47' N lat., 73°17' E long. and 56 m above MSL). Experiment was laid out in RBD with 3 replications and variety used was GNJ-1. The other practices were followed as per university recommendations. The results revealed that initial and final plant stand, days to 50% flowering and days to maturity remained unaffected due to weed management treatment. Treatment T_2 significantly reduced weed density (10.89 no./m^2) and weed dry weight (6.0 g/m^2) and was at par with T_{10}, T_9, T_8 which *fb* T_7. Significantly highest weed control efficiency achieved with treatment T_2 (94.2%) which *fb* T_8 (88.3%), T_9 (86.2%) and T_{10} (84.7%); whereas, significantly minimum value of weed index recorded with T_8 (6.3%) which *fb* T_7 (10.5%) and T_{10} (14.8%). The treatment T_2 recorded taller plant (233.8 cm), maximum panicle length (31.0 cm) and 100 seed weight (2.77 g) and was at par with T_8 and T_7. Consequently significantly higher grain and stover yield harvested with treatment T_2 (3215 and 12963 kg/ha) and was at par with T_8 (3015 and 12306 kg/ha), which *fb* treatment T_7 (2888 and 11365 kg/ha). Treatment T_2 generated maximum net returns (₹ 77299/ha) which *fb* treatment T_8 (₹ 73751/ha) and T_7 (₹ 66671/ha), whereas treatment T_1 gave lowest net returns (₹ 42545/ha). Based on the results of three years experimentation treatment T_2 i.e. hand weeding at 25 and 50 DAS + inter-culturing at 50 DAS and treatment T_8 i.e. atrazine 1.5 kg/ha PE *fb* one hand weeding at 40 DAS were found most effective. But under the circumstances of labour scarcity, treatment T_7 (atrazine 1.5 kg/ha PE *fb* halosulfuron methyl 100 g/ha PoE at 40 DAS) which involved complete chemical weed management would be ideal for higher grain and stover production in sorghum crop.

TECHNICAL SESSION 12

Weed threat to biodiversity in forest, wasteland and aquatic ecosystem and socio-economic implications

Relationship between profile characteristics of farmers and adoption of improved weed management practices

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Weeds compete with crops for resources in different agro-ecosystems and reduce yield and quality. In spite of the development and dissemination of improved weed management technologies, the adoption level is comparatively low due to various limitations with farmers. Regional-level studies on adoption of various weed management practices in different crops would help understand the factors influencing adoption and to make necessary improvements in the technologies. In this context, a study was conducted in the Jabalpur district of Madhya Pradesh during the year 2020-21 to determine the relationship between farmer characteristics and the adoption of improved weed management practices in different crops. The investigation employed an ex-post facto research design. The state and district were selected purposively for the study. Subsequently, 6 blocks from the Jabalpur district were randomly chosen, and 2 villages were randomly chosen from each block. Thus, a total of 12 villages were chosen, and ten farmers who had adopted improved weed management practices (IWM) from each village were selected randomly. As a result, there were 120 farmer respondents in the sample. Data were collected, and respondents were grouped into low, medium, and high adoption categories based on their scores, using the equal interval method. Most of the respondents, regardless of the crop, had a medium level of adoption. The majority of farmers', *viz.* 56, 49, 50, and 55%who cultivate rice, maize, greengram, and wheat, respectively, had a medium level of adoption, followed by 28, 20, 26 and 25% showed a high level of adoption. While studying the relationship between profile characteristics and adoption level of IWM practices in rice, it was found that farming experience, extension contact, input availability, training in IWM and innovativeness significantly influenced adoption level. However, factors such as age, education, farm size, mass media exposure, information-seeking behaviour, farm mechanization status, risk aversion, and labour availability had no bearing on adoption level. In case of maize, all the dependent factors except farm size, risk orientation, and labour availability had influence on the adoption level. In case of greengram, age, farm size, and extension contact, education, IWM training, information-seeking behaviour, and innovativeness influenced respondents' adoption levels significantly. In case of wheat, the adoption level was influenced by extension contact, risk orientation, age, education, farm size, media exposure, information-seeking behaviour, innovativeness, and input availability. Overall, the farmers' adoption level varied depending on the crop they were growing. However, in all cases labour availability was a common factor that had no effect on the adoption level. At the same time, extension contact was a significant factor in all four crops.

Climate change impact on ecological interactions of aquatic weeds and their biocontrol agents

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Human induced climate change and biological invasions are two of the most persistent ongoing challenges today. A rapidly changing climate may directly or indirectly influence the invasion potential of a non-native plant species by altering the vectors and pathways of the recipient communities. Prediction of climate change impacts on ecosystem and its functioning becomes a challenging problem due to scientific uncertainties. These uncertainties arise as climate change and biological invasions interact with other existing stressors to shape the distribution, spread, diversity and abundance of species, substantially altering biodiversity, causing changes in phenology, genetic composition, species ranges, species interactions and ecosystem processes. Invasive aquatic plants, such as water hyacinth, alligator weed, giant salvinia, etc. often grow aggressively causing significant ecological and socio-economic impacts. Biological control of invasive species with host specific insects and plant pathogens is considered a cost-effective, permanent and environmentally friendly method. But on one hand where climate change is anticipated to benefit the invasive plant species, on the other hand how this will impact the biological control agents and the control mechanism is less known. Biological control in an aquatic ecosystem is largely influenced by highly eutrophic waters, cooler climates that slow the build-up of the biological control agent populations, frost, floods and inappropriate application of other control methods such as herbicide application that affect the agents or cause a reduction in the weed population thereby decimating the agent population. Elevated CO_2 and temperature, together with phytopathogenic infection or arthropod herbivory, can significantly modify plant biochemistry and hence plant defense responses. Similarly, the field performance of a microbial herbicide in terms of virulence, host-range, etc. depends on several biological traits of the organism and its environmental conditions. There is a greater need to examine approaches for predicting the invasiveness of non-native plants and their biocontrol agents, under changing environmental conditions and their ecological interactions and impacts. There is also a critical need for a wider study of ecological, behavioural, physiological and life-history responses to be addressed across a greater range of geographic locations, particularly in areas of high human population growth and habitat modification, like India. This paper reviews how modified interactions, between mutually interacting species, like spatial or phenological decoupling of herbivore-predator, host-parasite or plant-pollinator populations, etc. may have ecological and economic consequences globally in aquatic invasive species and their biocontrol agents under changing climatic conditions.

Evaluation of herbicides to control alligator weed (*Alternanthera philoxeroides*) in mid hills of Himachal Pradesh

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Alternanthera philoxeroides (Martius) Griseb, commonly known as 'Alligator weed', belongs to Amaranthaceae family and is a stoloniferous, perennial, herbaceous plant that can grow in littoral, aquatic and even in terrestrial sites. It is a native of the Parana-Amazon River region and the associated Rio de la Plata basin of southern Brazil, Paraguay and northern Argentina of South America. However, over the years due to its invasive nature it has invaded many countries around the world including; South East Asia, USA, China, Australia, India *etc*. It is an invasive weed that has the capability to imbalence natural systems, agriculture and recreational areas. In terrestrial situations, it steadily increases its biomass, displaces other species and contaminates agricultural lands. Alligator weed has various traits of tolerance against variety of physical disturbances and stresses such as rapid vegetative propagation and allelopathic potential that are responsible for its successful invasion in a diverse range of habitats and ultimately lead to difficulty in the management of its spread. Among the different management methods for controlling weeds, this invasive weed can be effectively managed by using herbicides. Thus, an open pot experiment was conducted during *Kharif* 2020 and 2021 at Research Farm of Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to evaluate various herbicides for the control of *A. philoxeroides*. The experiment was laid in completely randomized design with 3 replications and consisted of ten herbicide treatments, *viz.* glyphosate 1000 g/ha, paraquat 1000 g/ha, 2,4-D Na salt 1250 g/ha, 2,4-D ethyl ester 1000 g/ha, metsulfuron-methyl 4 g/ha, carfentrazone 25 g/ha, glufosinate ammonium 500 g/ha, bispyribac Na 20 g/ha, flumioxazin 200 g/ha, diuron 500 g/ha and one weedy check (control). All the herbicide treatments resulted in significantly better control of *A. philoxeroides* as compared to untreated control (weedy check). Glyphosate 1000 g/ha remaining at par with metsulfuron-methyl 4 g/ha provided significantly lower shoot count at all stages of observation during both years as compared to other herbicide treatments. These were followed by the application of 2,4-D ethyl ester 1000 g/ha and carfentrazone 25 g/ha which except for initial stage of observation (15 days after spray) gave results statistically similar to glyphosate 1000 g/ha and metsulfuron-methyl 4 g/ha from 25 to 55 days after spray. Different herbicide treatments also significantly influenced the weed biomass. At the end of observational period, no regrowth of this weed was recorded with glyphosate 1000 g/ha, metsulfuron-methyl 4 g/ha and 2, 4-D ethyl ester 1000 g/ha and therefore, the lowest weed biomass (g/m^2) and highest weed control efficiency (100%) was recorded with these herbicides. Since, glyphosate, metsulfuron-methyl and 2, 4-D ethyl ester demonstrated effective control of alligator weed in pot conditions, they can further be evaluated in field conditions to manage alligator weed.

Efficacy of non-selective herbicides under non-crop situations

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Non-crop areas are infested with diverse weed flora including annual, perennial grasses, sedges and broad-leaf weeds. Hence, there is a need to find out prominent post-emergence herbicide either alone or in combination with cultural practices for timely control of weeds. Here, field experiment was conducted during *Kharif* season of 2019-20 on non-cultivated area available at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari with a view to study the efficacy of non-selective herbicides against non-crop situation. The experiment was laid out in randomized block design with three replications and comprised nine weed management treatments, *viz.*, glyphosate 2.0 kg/ha (W_1), glyphosate 3.0 kg/ha (W_2), paraquat dichloride 3.0 kg/ha (W_3), paraquat dichloride 4.0 kg/ha (W_4), glyphosate + oxyfluorfen 2.0 kg/ha (ready-mix) (W_5), glyphosate 2.0 kg/ha + 2,4-D salt 2.0 kg/ha (tank-mix) (W_6), paraquat dichloride 2.0 kg/ha + 2,4 D salt 2.0 kg/ha (W_7), mowing (one weed flush) (W_8), weedy check (W_9). All weed management treatments significantly influenced the monocot, dicot and sedges weeds. The efficacy of mowing and paraquat dichloride alone or in combination with 2, 4-D excellently controlled weeds up to 10-15 days of application, onwards considerable resurgence of weeds would be observed. Application of glyphosate 2.0 kg/ha completely destroyed the total weeds upto 21 days, however effect was more acute with the higher rate of glyphosate 3.0 kg/ha which demolished the weeds upto 30 days after application (DAA). Under the dominancy of dicot weeds, application of glyphosate 2.0 kg/ha + 2, 4-D salt 2.0 kg/ha found most suitable, whereas, glyphosate 41% + oxyfluorfen 2.50% SC 2.0 kg/ha found appropriate where monocot weeds become dominant. Amongst all the weed management treatments glyphosate 3.0 kg/ha found effective and completely destroyed the growth of weeds, however, negligible biomass was observed at 60 DAA. There was no resurgence of monocot, dicot and sedge weeds observed at 30 DAA with glyphosate applied at 2.0 or 3.0 kg/ha and even negligible resurgence was observed at 60 DAA. However, glyphosate with either oxyfluorfen or 2, 4-D were effectively checked the resurgence of total weeds up to 21 DAA. Further, effect of glyphosate 2.0 kg/ha + 2, 4-D salt 2.0 kg/ha could persist longer and observed zero resurgence for dicot weeds. As far as economics is concerned, the cost of weed control was observed ¹ 2046/ha under the application of glyphosate 2.0 kg/ha, which was further raised with higher dose or in combination that observed almost equal effective. Hence, Glyphosate found much better as compared to other herbicides and crumbed the monocot, dicot and sedge weeds hundred percent within fortnight and checked the resurgence for a month with negligible resurgence at 60 days of application. Thus, it is advised to apply glyphosate 2.0 kg/ha for effective and economic control of weeds in non-cropped land.

Composting as a sustainable option for managing biomass of aquatic weed

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Aquatic weeds have appeared as critical hazards to the freshwater bodies in both tropical and temperate zones. Some of these plants (especially microphytes) form the basis of the food supply in the aquatic system by fixing the photo-energy into chemical energy through photosynthesis mechanism. Such weeds are food for many herbivores in water bodies, the excessive growth of these plants, particularly in summer causes the severe damage to the aquatic environment. The nutrient enrichment of water bodies through the mixing of wastewater causes excessive growth of these weeds, which result in the formation of a thick layer of phytomass over the aquatic bodies. This process restricts the light penetration and gaseous exchanges in freshwater bodies results in the destruction of the aquatic environment. The weeds cause severe damage to irrigation and hydro-energy projects by clogging the irrigation canals, restricting the water flow, blocking in the machinery of hydroelectric dams, causing water loss through evapotranspiration, deteriorating the water quality, *etc*. Composting is one of the efficient methods for turning organic solid wastes into a product with value-added for agronomic use. In this study, the aquatic weed *Pistia sp*. (water lettuce) biomass was co-composted with cow dung in 1:1 and 3:1 ratios, and changes in physicochemical properties were measured during the process. To observe the scaling effects of cow dung on the composting process, one set up with 100% plant biomass was also retained. Under ambient conditions, the composting was carried out in 50 kg rectangular plastic boxes. A decrease in pH (0.21-4.57%), total organic carbon (2.42-22.5%) and, carbon to nitrogen ratio (15.59-41.13%) ratio and increase in total N (15.61-22.14%), total P (29.75-50.67%), total K (30.3-81.59%), total calcium (15.17-26.07%), zinc (26.07-42.72%), iron (16.39-24.26%) and, copper (29.18-34.18%) were recorded during the composting process. The results of the microbial enzyme (dehydrogenases, protease, and phosphate) suggested the high rate of microbial activities and organic matter mineralization during the composting process. The seed germination index and soil respiration rate suggested the non-phytotoxic and microbially stable properties of composted waste mixtures. The maximum waste mineralization was in compost setup with a 50% proportion of plant biomass. Thus, composting can be a cleaner option to convert aquatic weed biomass into added-value materials for sustainable agriculture programs.

Local adaptations and seed production rate of *Lantana camara* in the tropical forests area

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India is is blessed with a rich biological diversity and ranks 6th amongst the 12 mega-biodiversity nations of the world. India houses approximately 18% of endemic flora, which includes 4,900 species of flowering plants that are found nowhere else in the world. The direct destruction (through inappropriate resource use or pollution) of ecosystems by humans is one of the biggest dangers to biodiversity on the globe. The threat posed to natural and semi-natural environments by the invasive alien species (IAS), which has the potential to be a long-lasting and pervasive danger, is another major but underappreciated issue. The aim of present study was to assess the local adoptions and seed production rate of *Lantana camara* in eradicated site. The present study was conducted in the tropical forest area of Chhattisgarh. An extensive field survey was carried out. On the basis of field observations, the local adaptations: *Lantana camara* re-established itself easily even after uprooting in the Amarkantak hill areas due to the moist and humid climatic conditions as it grows well in rocky, shallow soil depth areas with over-head sunlight availability. The seed production rate is crucial for the expansion and establishment of plant species. The average seed production rate of a single flower was 25 to 29 seeds per flower at Karitarai (PF 1430), and 28 to 33 seeds per flower at Takraguda (OA 540). The average number of flowers per matured plant was 250 to 400. The average seed production rate was 6250 to 13200 seeds per plant. The study revealed that this notorious weed is easily adapted to different types of harsh environmental and soil conditions and has high seed production potential. This study will be helpful to foresters, scientists and other stakeholders in development and adoption of sound management plan to reduce the invasion of *Lantana camara* to natural habitat areas.

Occurrence of alien invasive weed *Mikenia micrantha* Kunth in one of the districts of Madhya Pradesh shows its expanding invasion in Central part of India

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One of the greatest threats to global biodiversity is species invasion. Biological invasions have been considered to be one of the three most difficult environmental problems in the world. *Mikania micrantha* Kunth is native to South and Central America, where it is widespread but is not considered a weed. After it's introduced into the Asia-Pacific region it has been reported from 20 countries in the South-Pacific region and from most of the countries in South-East Asia. However, in some countries including Australia, China and India, its distribution within the country is limited, most probably due to weather and altitude conditions. *M. micrantha* is one of the 10 most invasive weeds in the world. *M. micrantha* is a tropical plant of the family Asteraceae, known as bitter vine, climbing hemp vine, or American rope. It is also sometimes called mile-a-minute vine. In north-eastern part of India, it is also known as Japani lota. Although, *M. micrantha* was reported first time in India in 1918, but it is also considered that this was introduced into India again during World War II. *M. micrantha*, has been reported as a serious menace in agricultural and non-agricultural areas of North-East and Kerala states and is a great problem in rubber, coconut, arecanut, cocoa, coffee plantations and in annual crops like pineapple, banana and tapioca. In Assam, among the coffee estates surveyed, the highest infestation of *M. micrantha* was observed in the estates surrounded by open forests and neglected other plantation crops which served as a good seed source for this weed. Since the 1980s it has started to spread and invade other Indian states like West Bengal in 1981, Western Ghats in 1993 and Karnataka in 1997, Tamilnadu in 2008, Uttar Pradesh in 2009 and Andhra Pradesh in 2009. Recently, *M. micrantha* has been recorded in Sarni town of district Betul of Madhya Pradesh. It is a new record of its occurrence in central India where there are great fluctuations in temperature and rainfall. The weed was found in greater density in the area where ash of Thermal Power Generating Plant is dumped in comparison to other areas of the town. It was found to climb on the trees. A survey was made outside of the Sarni to find its invasion in other areas. The intensity of its occurrence reduced towards outside of the town and become nil thereafter. Watching the incursion pattern of *M. micrantha* in India, it appears that it had already invaded North-East and South-Western part of the country including Karnatka, Tamil Nadu, Odisha and has now started to invade new areas like Central and North India. Since control methods for this noxious weed have not so far proved, suitable attention should be concentrated on regular monitoring to record its pattern of spread so that effective measures can be initiated to contain its growth before it become invasive and uncontainable. General awareness about its negative impacts should also be raised so that people can report its presence in new areas for proper records of its spread.

Effect of *Chromolaena odorata* invasiveness on native biodiversity in southern Chhattisgarh forests

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Chromolaena odorata is an invasive plant species belonging to *Asteraceae* family considered to be one of the most aggressive weeds in tropical and sub-tropical areas. The native range of *C. odorata* is in America, extending from Florida to northern Argentina. *C. odorata* or Siam weed is reportedly one of the world's worst invasive weeds and is a serious threat in central and western Africa, India, Australia, the Pacific Islands and Southeast Asia. Despite several efforts to control *C. odorata*, it has been a menace in forest areas affecting the native diversity, preventing germination or growth of other vegetation. A survey was conducted to study the impact of *C. odorata* on the diversity and richness of native plant species in Chhattisgarh forests. Permanent plots were established along transects in invaded understory vegetation and uninvaded area of Bastar Forest Division, Chhattisgarh. *C. odorata* invaded and uninvaded sites were identified and sampling was done in five random quadrats (10 × 10 m) per site. Sites were categorized as high, medium and low density of *C. odorata* infestation. Differences in native species richness and *S. robusta* seedling density was observed between invaded and uninvaded plots. The invaded plots are associated with fewer species of *Cassia tora, Smilax* spp.*, and Asparagus racemosus* than uninvaded plots. *C. odorata* density and invasiveness showed effect on vegetation composition. Maximum *C. odorata* density infestated areas have low density of native biodiversity of existing herb plants *Randia uliginosa*, *Curculigo orchioides* and others when compared to the areas where the population of *C. odorata* was low or absent. Similar result was obtained for herb seedlings like *C. tora, Smilax spp, A. racemosus.* Plot type (invaded and uninvaded), The native species were found to get replaced in *C. odorata* invaded sites. *C. odorata* infestation impact on *S. robusta* seedlings indicates threats to natural regeneration of high valuable tree, which is of great concern. It is expected that the intensity of *C. odorata* invasion would be increased more severely activities of controlling and management of this weed are not undertaken. Therefore, control and proper management of *C. odorata* is needed for conserving native vegetation and preventing future problems associated with its invasion.

Evaluation of tillage and weed management practices on soybean

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A field experiment entitled "Effect of tillage and weed management practices on soybean (Glycine max L.)" carried out during *kharif* season of 2021 with fifteen treatment combinations comprising, three tillage management practices, *viz.*, reduced tillage (T1), minimum tillage (T2) and conventional tillage (T3) and five weed management practices, *viz.* two interculturing + two hand weeding at 20 and 40 DAS (W1), pendimethalin (pre-emergence) 0.9 kg/ha + 1 IC + HW at 40 DAS (W2), pendimethalin (pre-emergence) 0.9 kg/ha + pre mix sodium acifluorfen + clodinafop-propargyl 165 + 80 g/ha as post-emergence at 40 DAS (W3), interculturing + hand weeding at 20 DAS + pre mix sodium acifluorfen + clodinafop-propargyl 165 + 80 g/ha as post-emergence at 40 DAS (W4) and Weedy check (W5) were evaluated in split plot design with three replications.

Results revealed that conventional tillage (T3) recorded significantly higher growth, and yield attributing characters of soybean viz., plant height at 30 DAS and at harvest, number of root nodules per plant at 60 DAS, number of branches per plant at harvest, number of pods per plant, number of seeds per pod and length of pod which ultimately increased seed and stover yields and remained at par with treatment minimum tillage (T2). The lowest weed count and dry weight of weeds were also recorded under conventional tillage which remained at par with minimum tillage. However, weed control efficiency found higher under conventional tillage. Maximum gross and net realization were also recorded under conventional tillage but the higher B:C ratio was noted in minimum tillage.

Significantly maximum plant height at 30 DAS and at harvest, number of root nodules per plant at 60 DAS, number of branches per plant at harvest, number of pods per plant, number of seeds per pod, length of pod, seed and stover yields were registered under W1 remained at par with treatment W4. Significantly lower weed count and dry weight of weeds were also recorded under W1 which remained at par with W4 and W2. However. Weed control efficiency was also found higher under W1. Maximum gross and net realization were also recorded under W1 but the higher B:C ratio was noted in W4.

An interaction effect due to various tillage and weed management practices on number of pods per plant, seed yield, dicot weed count at 60 DAS and at harvest and dry weight of weeds were found to be significant. It was found that treatment combination T3W1 produced significantly higher number of pods per plant and seed yield and lower dicot weed count at 60 DAS and at harvest and dry weight of weeds at harvest. Which was closely followed by the treatment combinations T3W4, T2W2 and T2W1. Maximum gross and net realization were also recorded under W1 which is closely followed by W2 and W4 and higher B:C ratio was registered under W4.

Poster 210

Effect of pre- and post-emergence herbicides on growth and yield of *Kharif* grain sorghum

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Sorghum is affected by weeds and the loss due to weeds account for 33 per cent of the potential production and 30 to 45 per cent of the plant nutrients from the soil. Traditional hand weeding is the most efficient and widely adopted practice of weed management but it is labour intensive, time consuming and not economical due to high wage rates. Chemical weed control is a better supplement to conventional method however the weed emergence pattern, application timing and stage of crop are important in chemical control. A field experiment was conducted at AICRP on Sorghum, Main Sorghum Research Station, Navsari Agricultural University, Surat (Gujarat) during Kharif season of the year 2021 under deep black soil. The experiment was laid out in randomized block design with two replications and sixteen treatments with pre- and post- emergence herbicides (Atrazine, Metolachlor, Bentazone, Mesotrione, Carfentrazone-ethyl and 2,4-D Na Salt) alone or combination of these herbicide followed by Weed free (Two hand weeding at 15 and 35 DAS). Among the growth parameters, plant height, days to 50% flowering and days to maturity were not affected significantly due to various weed management treatments. Treatments of Weed free (Two hand weeding at 15 and 35 DAS) recorded significantly higher grain (3.60 t/ha) and straw (12.73 t/ha) yields. However, grain and straw yield were remained at par with treatments T1 *i.e.* Atrazine 50 WP 0.50 kg/ha (pre-emergence, PE), T4: T1 + bentazone 480 g/l SL 960 g/ha as PoE at 3-4 leaves and T13: T1 (PE and PoE), respectively. Same result was observed in biological yield. The lowest grain, straw and biological yield were obtained under weedy check. The maximum net returns (98853 Rs/ha) was realized under the treatment of T1: Atrazine 50 WP 0.50 kg/ha (pre-emergence, PE) fb treatments T15: Weed free (Two hand weeding at 15 and 35 DAS) fb T13: T1 (PE and PoE). Whereas, the maximum B:C was recorded under the treatment T1 *i.e.* atrazine 50 WP 0.50 kg/ha (pre-emergence, PE) (3.23) fb treatments T13: T1 (PE and PoE) fb T15: Weed free (two hand weeding at 15 and 35 DAS). Atrazine (PE) is as profitable as weed free situation. So there is a need to different pre- and post-emergence herbicides in sorghum, which should be efficient, cost effective and suitable. Keeping these facts in view, a study has been attempted.

Efficacy of pre- and post-emergence herbicides for weed management in chickpea

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A field experiment on the f eficacy of pre- and post-emergence herbicides for weed management in chickpea (*Cicer arietinum* L.) was carried out during *Rabi* season of 2016 at College of Agriculture, JAU, Junagadh. The experiment comprising 12 treatments was laid out in randomized block design with three replications.The results revealed that next to the weed free treatment, significantly higher values of growth parameters *viz*., plant height, number of branches/plant and leaf SPAD value at before spray and after spray, yield attributes and yield *viz*.,number of pods/plant along with seed yield and stover yield, quality parameters *viz*., protein content and N, P and K content and uptake by seed and stover were recorded with pre-emergence application (PE) of oxyfluorfen0.18kg/ha followed by (*fb*) imazamox + imazethapyr (pre-mix) 0.03 kg/ha post-emergence application (PoE) at 40 days after seeding (DAS) and hand weeding (HW) twice at 20 and 40 DAS. Higher status of available N, P and K in the soil after harvest of the crop was registered under weed free (T_{11}), which was at par with T_8 : oxyfluorfen 0.18 kg/ha as PE fb imazamox + imazethapyr (pre-mix) 0.03 kg/ha PoE at 40 DAS and T_{10} : HW twice at 20 and 40 DAS.Afterwards weed free (T_{11}), T_8 : oxyfluorfen 0.18 kg/ha PE *fb* imazamox + imazethapyr (pre-mix) 0.03 kg/ha PoE at 40 DAS, T_{10} :HW twice at 20 and 40 DAS, T_2 : oxyfluorfen 0.18 kg/ha PE *fb* 1 HW at 40 DAS and T_1 : pendimethalin 0.9 kg/ha PE *fb* 1 HW at 40 DAS were found effective in controlling sedge, monocot and dicot weeds up to harvest and resulted in less weeds biomass, lower weed index and higher weed control efficiency and herbicidal efficiency index. The highest net return of Rs. 72040/ha was realized with oxyfluorfen 0.18 kg/ha PE *fb* imazamox + imazethapyr)0.03 kg/ha (pre-mix) PoE 40 DAS followed by the treatments weed free and HW twice at 20 and 40 DAS. However, the highest B:C ratio of 3.54 was obtained with oxyfluorfen 0.18 kg/ha PE *fb* imazamox + imazethapyr) 0.03 kg/ha (pre-mix) PoE at 40 DAS.

Herbicides efficacy for managing weeds in clusterbean and their residual effect on succeeding mustard

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A field experiment on weed management in clusterbean was conducted during the consecutive years of kharif 2020 and 2021 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur. The test crop was grown with nine weed management treatments [pendimethalin 750 g/ha PE *fb* hand weeding (HW) at 40 DAS, Imazethapyr 60 g/ha PoE *fb* hand weeding (WH) at 40 DAS, pendimethalin + Imazethapyr (RM) 750 g/ha PE + handweeding (HW) at 40 DAS, imazethapyr+ imazamox (RM) 60 g/ ha PoE *fb* hand weeding at 40 DAS, aciflourfen + clodinafop (RM) 245 g/ha PoE, imazethapyr 60 g/ ha PoE + quizalofop (TM) 60 g/ha PoE, oxyflurofen 150 g/ha PE *fb* imazethapyr 75 g/ha PoE, hand weeding at 20 and 40 DAS and weedy check] and two level of vermicompost (0, and 5 t/ha), and the experiment was laidout in RBD with three replications. Among different weed control treatments, hand weeding at 20 and 40 DAS, pre-emergence application of pendimethalin + imazethapyr (RM) 750 g/ ha *fb* handweeding (HW) at 40 DAS and post-emergence of imazethapyr + imazamox (RM) 60 g/ ha *fb* hand weeding at 40 DAS were more effective in respect of reducing weed density, weed biomass, nutrient removal by weeds and to promote yield and quality of clusterbean as compared to rest of other weed control treatments.The dominant weed species among monocot weeds were *Echinochola crusgalli, Eleusine indica, Commelina benghalensis, Digitaria sanguinalis, Eragrostis major, Cynodon dactylon* and *Cyperus rotundus,* however among dicot weed species *Digera arvensis, Phyllanthus niruri, Amaranthus viridis, Oldenlandia umbellate, Euphorbia hirta* and *Spergula arvensis* were also found during the growing seasons. Weed dry weight of monocot and dicot weeds was the lowest in hand weeding carried out at 20 and 40 days after sowingwhich was at par with pendimethalin+imazethapyr (RM) 750 g/ ha pre-emergence followed by hand weeding at 40 days after sowing. Highest seed yield (1.96 t/ha) and halum yield (6.38 t/ha) of clusterbean were also recorded in hand weeding at 20 and 40 DAS but maximum net return (Rs.86883/ha)was recorded in pre-emergence of pendimethalin + imazethapyr (RM) 750 g/ ha *fb* HW 40 DAS closely followed by imazethapyr + imazamox (RM) 60 g/ha (Rs.85398/ha)and two hand weeding at 20 and 40 DAS. Application of herbicides did not cause any residual phytotoxic effects on succeeding crop of mustard in both years.

Impact of *Echinochloa colona* (L.) Link. on the physiology of rice under elevated CO_2 and temperature

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Climate change is affecting agricultural productivity worldwide. According to the Intergovernmental Panel on Climate Change, 2014 report, the global surface temperature is estimated to rise by 1.5 °C relative to 1850 by the end of the 21st century and the concentration of atmospheric carbon dioxide (CO_2) is estimated to exceed 560 ppm by 2050. Depending on the agroecological conditions of the region, these changes can have a detrimental effect on crop productivity and food security. Crop growth and productivity are greatly influenced by different biotic stresses (eg. weeds) and abiotic stresses (eg. drought, salinity and extreme temperature). Weeds are likely to show greater resilience and better adaptation to changes in CO_2 concentrations and rising temperature in competition with crops due to their diverse gene pool and more remarkable physiological plasticity.

This study was aimed to study the response of a weed (*Echinochloa colona* (L.) Link.) grown along with rice to ambient, elevated CO_2 (550±50 ppm), elevated temperature (ambient + 2 °C) and combined effect of elevated CO_2 and temperature. The interference of *E. colona* severely impaired the growth and the performance of rice under elevated CO_2, elevated temperature and due to the combined effect of elevated CO_2 and temperature in comparison to ambient condition. Gaseous exchange parameters like rate of photosynthesis, stomatal conductance and transpiration were found to be altered in the presence of *E. colona*. It was noticed that the rate of photosynthesis of rice was reduced by 27.93, 32.16 and 18.73% under elevated CO_2, elevated temperature and in the combination of elevated CO_2 and temperature, respectively in comparison to ambient. Similarly, the rate of transpiration of rice declined by 65.22, 24.31 and 47.19% under elevated CO_2, elevated temperature and in the combination of elevated CO_2 and temperature, respectively compared to ambient.

The present study revealed that elevated CO_2 and elevated temperature had a positive impact on *E. colona* growth. It was noticed that the growth and biomass of the *E. colona* were higher in elevated CO_2 and elevated temperature compared to ambient. This decreased the rate of photosynthesis and altered the gaseous exchange parameters. From the results of the present investigation, it can be concluded that *E. colona* will become a major problematic weed in the futuristic climate change scenario. Therefore, a thorough understanding of crop responses to weeds under elevated CO_2 and temperature conditions is required to meet the food and nutritional security of the world and develop effective agricultural production adaptation strategies under changing climate scenarios.

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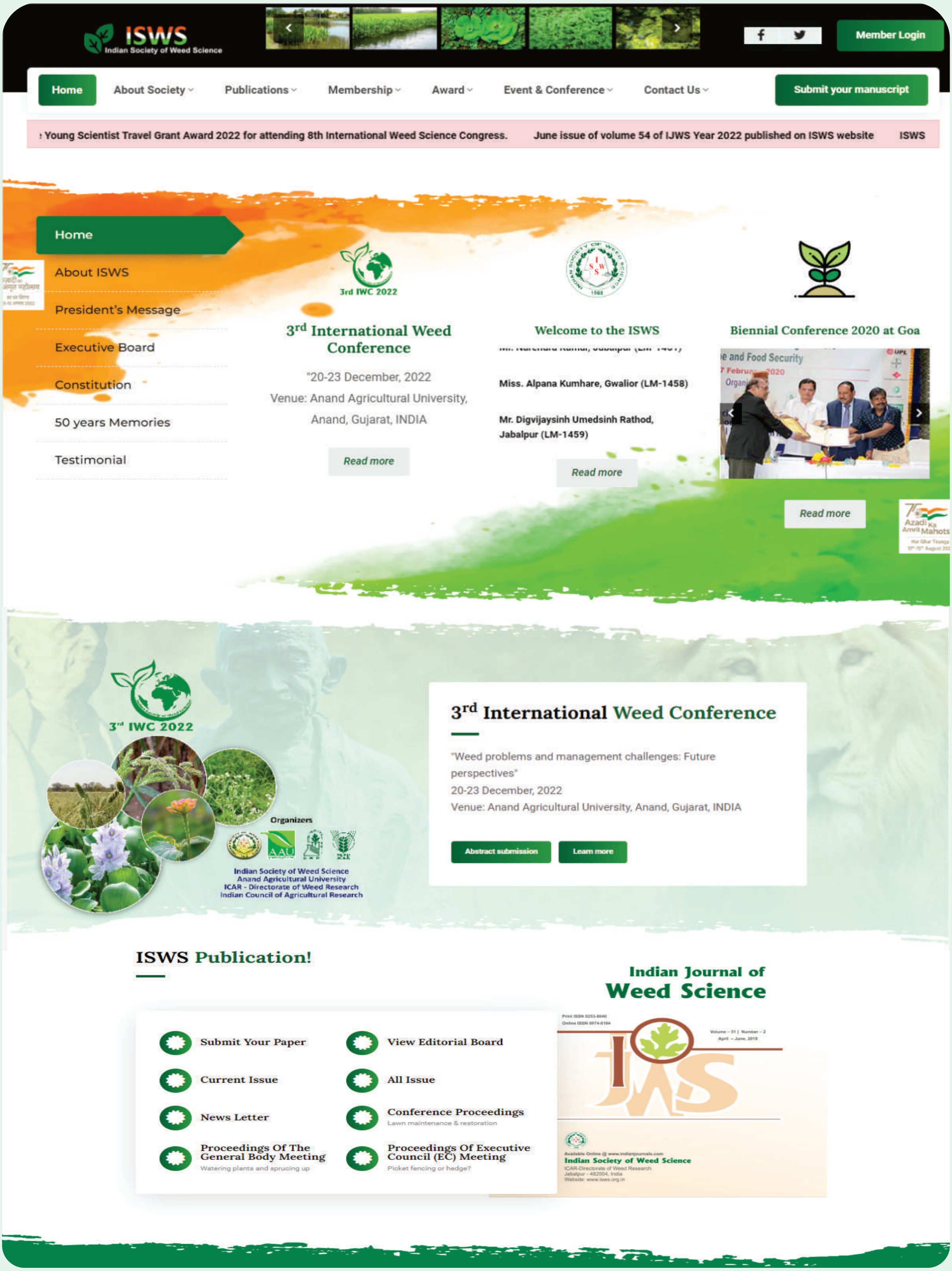

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