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Book of Abstracts

Precision Horticulture for Improved Livelihood Nutrition and Environmental Services

H.P. Singh
Dinesh Kumar

Jain Irrigation Systems Ltd
Jalgaon
May 28-31, 2023

15th Swadesh Prem Jagriti Sangosthi - 2023

Global Conference on
Precision Horticulture for Improved Livelihood, Nutrition and Environmental Services

Jain Irrigation Systems Ltd. (JISL), Jalgaon, Maharashtra, India

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Preface

Lt. Amit Singh Memorial (ASM) Foundation, committed to achieve its goal and mission, is carrying out various activities since its inception, in 2001 beside conference and Sangosthi. To achieve its objectives, the ASM Foundation has instituted ten awards in various categories and is committed to give impetus to the overall growth of the society. The ASM Foundation is also committed for the cause of farmers in India. It is leaving no stone unturned in taking lead for motivating farmers for overall development of agriculture/ horticulture at the national level. I am happy to share with you that, an Institutional Excellence Award-2017 was conferred on ASM Foundation in recognition of outstanding contributions for reconstruction of Rural India through involvement of youth in agricultural transformation, by AIASA, New Delhi. The CNRI, New Delhi also recognised the contribution of Lt. Amit Singh Memorial Foundation in developing patriotic society by conferring Appreciation Award-2019.

The Foundation recognises the outstanding contributions of the leaders in the development of agriculture and horticulture, through the science, technology and policies. To recognise the industry and its leaders, the Foundation confers awards to them. To recognise the outstanding contributions for transforming national agricultural scenario, awards like Amit Krishi Rishi, Amit Padam Jagriti and Amit Prabudh Manishi are conferred on distinguished agriculturists/ horticulturists. Highly motivated innovative horticulture farmers, who are keen and receptive to learn advanced technique for technology led development and have displayed their competence by refining technologies to suit local conditions at district or state level, are conferred with Amit Udyan Ratna Award, to sustain the momentum of positive change and encourage other farmers. Amit Swah Award recognises the distinguished services of the leaders in wellness of mankind. To encourage intelligent brains and to develop path-breaking concept notes of practical relevance, Amit Agrani Award was instituted for young scientists, up to the level of senior scientists, for their creative thinking and conceiving new concept. Every small bit of contribution is important to secure national level success of mega projects, but very often these contributions remain unnoticed. The Foundation has initiated Best Performing AICRP Coordinating Centre Award for AICRPs. The Lt. Amit Singh Memorial Medal for the best student has also been instituted at Dr. YSR Horticulture University and Junagadh Agricultural University, Junagadh.

I am happy to present this Book of Abstract-2023. The Foundation has been organising the Global conferences and Swadesh Prem Jagariti Sangosthi every year. This conference is 15^{th}in the series and highly topical as well as important to address the challenges. This Book of Abstract-2023 has detailed information about the articles. I express my sincere gratitude to Dr. H.P. Singh, and the team for their hard work in compilation of abstracts and editing. I am sure this book will be of great value to all the stakeholders. Finally, I thank all those who worked hard to bring out this book.

Bimala Singh
Managing Trustee LASMF

Epilogue

Horticulture, which includes fruits, vegetables, flowers, spices, medicinal and aromatic plants, and plantation crops, is becoming increasingly important for socio-economic development. The rise in dietary preferences towards healthier options, combined with increased income, has resulted in a growing demand for horticultural produce. The challenge, however, is to meet this demand with limited land and water resources, in the face of climate change.

Precision Horticulture is a technology-driven approach that uses data analysis and digital tools to optimise farming practices. The precision systems can be used to improve the efficiency and effectiveness in sustainable farming practices, including soil management, water use, and crop production. It offers a solution to this challenge by using precise inputs to optimize production and increase efficiency, quality, and environmental sustainability. This approach involves the use of technology, management, and information to reduce intra-variability and collect and analyze data. Tools used in precision horticulture include Positioning Systems (e.g., GPS), sensors, GIS, Variable Rate Fertilizer (VRF), precision irrigation (PI), and software.

Recognising the need for the adoption of precision horticulture and the development of strategies for larger adoption, the **ASM Foundation, New Delhi, in association with Jain Irrigation Systems Limited, Jalgaon,** is organising a Global Conference on **Precision Horticulture for Improved Livelihood and Environmental Services.** The conference seeks to provide a platform for knowledge-sharing and collaboration among stakeholders to develop strategic recommendations for policy frameworks and analyze the current status of horticulture. It will also analyse the impact of precision horticulture on production and productivity, livelihood, nutrition, and environmental services.

AIMS AND OBJECTIVES

The main aims and objectives of the conference are as follows:

1. To analyse the past trend and develop strategies for the larger adoption of precision horticulture.
2. To provide a platform for knowledge-sharing among stakeholders for developing strategic recommendations for policy frameworks.
3. To understand the current status of horticulture and the impact of precision horticulture on production and productivity, livelihood, nutrition, and environmental services.
4. To encourage the development of technologically viable, futuristic research for improved livelihood options.
5. To enhance knowledge, identify innovative practices, and encourage opinion and innovation.
6. To showcase and promote precision horticulture products and services.

CONFERENCE STRUCTURE

The conference will be structured around 14 technical sessions, with introductory and valedictory sessions, an open session for industry, entrepreneurs, and field functionaries, and several important activities. The technical sessions will cover various technological areas, and each session will be identified and moderated. The panelists will be given optimum time for sharing their views with PowerPoint presentations.

In addition to the technical sessions, several important activities will be hosted, including:

1. Horticulture Expo-2023: An exhibition showcasing precision horticulture products and services.
2. National Level Essay Competition: A competition for students to showcase their ideas and knowledge on precision horticulture.
3. Farmers' Quiz: A competition for farmers to test their knowledge on precision horticulture.
4. Mango Eating Competition: A fun activity to promote the consumption of mangoes.
5. Distribution of Quality Seeds & Planting Material: Seeds and planting material will be distributed to the farming community.
6. Conferment of Awards: Awards will be presented to recognize outstanding contributions in precision horticulture.
7. Post Conference Tours: Tours will be organized for participants to visit horticulture-related sites and locations.

SHODH CHINTAN The Shodh Chintan will be published, providing an opportunity for sponsorship, advertisements, and showcasing activities. The publication will feature articles and research papers on precision horticulture and related topics.

The Global Conference on Precision Horticulture for Improved Livelihood and Environmental Services,seeks to provide a platform for knowledge-sharing and collaboration among stakeholders to develop strategic recommendations for policy frameworks and analyse the current status of horticulture. The conference will deliberate and discuss in 14 technical sessions besides inaugural and plenary session. The recommendations emanated from the conference shall be circulated to stakeholders for implementations. I look forward for your effective participation in deliberation.

Ashok B. Jain
Chairman
Jain Irrigation Systems Ltd., Jalgaon

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PARADIGMS IN PRECISION HORTICULTURE TO ADDRESS THE CHALLENGES OF PRODUCING MORE WITH LESS

1.1 Plenary Lecture

1.1.1 Precision horticulture for improved livelihood, nutrition and climate resilience

H.P. Singh

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Precision horticulture, a management strategy, gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, enhanced productivity, improved quality, increased profitability and sustainability. Consequently, it is a concept concept based on observe, measure and respond to get maximum output from given inputs, in other words get more with less.It is implemented as data management strategies which reduces the variability and gives optimised output.The use of PH (Precision Horticulture) technologies in particular is aimed at ensuring sustainable intensification across all aspects of production system including food chain. In this system, technologies are designed to deliver, economic benefits through reductions in farm expenditure via the controlled application of inputs, increased production levels due to targeted management of in-field or intra-animal variability and environmental benefits through the precise application of inputs which will also meet the environmental compliances. Precision system often uses technologies to automate operations for improved diagnosis of the problem to address appropriately, The first wave of the precision system revolution came in the forms of satellite and aerial imagery, weather prediction, variable rate fertiliser application, and crop health indicators. The second wave aggregates the machine data for even more precise planting, topographical mapping, and soil data, The precision needs the equipment which is wired with the right technology and data systems including Variable rate technology (VRT), Global positioning system and Geographical information system, Grid sampling, and remote sensors. Precision agriculture is an application of breakthrough digital technologies for horticulture farming system and value Chain Management.

Exponential advancement in horticulture coupled with digitalisation, use of censors, ICT, remote servicing and robotics for different type of farming and horticulture business is becoming important referred to as Digital Horticulture. In the digital horticulture digital images and sensors are used and integrated, and robotics and machine learning are adopted. Digital horticulture aims to improve industrial metrics such as, yield, profit and sustainability and to transform the sector's commodity trading, purchase of inputs, and traceability of product. The techniques used are Block Chain, IoT (Internet of things) and data information platform. The Block Chain is a type of distributed ledger that is used to capture, organise, and validate data in almost every aspect of Digital Horticulture, which needs IoT based data collection. This also includes contract and certificates that can be executed. Blockchain makes complex transaction quicker and cheaper to execute, which benefits the stakeholders. This also offers accurate and early traceability of all the produce from the exact spot, where it was harvested to the retail outlet. Accurate accountability becomes quick and easy and appropriate action takes place. IoT (Internet of Things) is the network of physical devices that collect, connect and exchange data. The devices measure variability of parameters at multiple places for effectively managing the crop. The crop management is tailored on information. Edge computing and machine learning capability are essential to improve data from IoT devices. The secure data storage can safely accommodate the large amount of data which is generated by the physical devices. A well architected Artificial Intelligence (AI) helps in achieving higher yields while optimizing resources efficiency, hence enabling farm to be more sustainable, viable and profitable. Next revolution of horticultural practices will be dominated by AI and human wisdom in future. However, AI (Artificial Intelligence) has to be integrated with IA (Information Architecture). Digital marketing, referred as online marketing is a promotion of brands to connect with potential customers using the internet and other form of digital communication. This includes use of the entire digital platform. The digital marketing of horticultural activities could be a platform of content marketing, search engine optimization (SEO) Search Engine marketing (SE) and social media marketing. There is a growing interest on digital horticulture, using e-platform for information exchange and management, not only for marketing but also for production system management and value chain management using various types of data driven platform for decision making. Therefore, Digital horticulture provides a lot of opportunities and also the challenges. The paper discusses the details.

1.1.2 Sensor based management of production system in horticulture

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Indian horticulture sector contributes about 33% to the agriculture Gross Value Added (GVA) making very significant contribution to the Indian economy. Apart from ensuring nutritional security of the nation, it provides alternate rural employment opportunities, diversification in farm activities, and enhanced income to farmers. In recent years, horticulture has been revolutionized by the introduction of precision agriculture technology. Precision horticulture is an advanced technology that involves smart farming practices that result in increased crop yields, reduced input costs, and improved profitability. Digital technology such as robots, drones, sensors, IoT, AI, GIS, GPS, remote sensing etc in precision horticulture is widely practiced in developed countries, is still a nascent stage in most of the developing countries which needs integrated and sustainable efforts.

Emerging precision agriculture technologies rely heavily on remote sensing geographic information system (GIS), global positioning system (GPS), auto analyser, sensors, computers along with appropriate software, etc. for precisely identifying areas of nutrient deficiencies and other biotic and abiotic stresses, etc. and quantification of the economic significance of soil, water, fertilizer, pest, crop related constraints and their environmental impacts at the farm/village/region levels. They can provide useful guidance for adopting the systems of integrated management of soil health, nutrients, pests, water, energy and different crop genetic resources. The main objective of adopting precision farming in India is to improve agricultural production, quality of environment and economic status of the farmers. The enabling technologies, which enhance the acceptability of precision farming and horticulture in the eyes of farmers, planners and scientific community, can be grouped into three major classes viz, GPS, GIS and remote sensing. The most common use of GPS in agriculture is for yield mapping and variable rate fertilizer/pesticide applicator. The GPS are important to find out the exact location in the field to assess the spatial variability and site-specific application of inputs. The GPS operating in differential mode are capable of providing location accuracy. The GIS is an organized collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographically referenced information. It is the spatial analysis capabilities of GIS that enable the precision horticulture. The GIS is the key to extracting value from information on variability. It is rightly called as the brain of precision farming. It can help in agriculture in two ways. One is in linking and integrating GIS data (soil, crop, weather field history) with simulation models. Other is to support the engineering component for designing implements and GPS guided machineries (variable rate applicators) for precision agriculture. By using the appropriate source data, it is possible to use a GIS in order to model processes that are affected by such data, and predict what the effect of this process will be in the future. Remote sensing holds great promise for precision agriculture because of its potential for monitoring spatial variability over time at high resolution. The advantages of using remote sensing technology are to obtain spatially and temporally variable information for precision farming. Remote sensing imagery for precision farming can be obtained either through satellite-based sensors or sensors based drones. Remote sensing can be used as source of different types of information for precision horticulture. The use of drones in conjunction with sensors has also gained interest in recent years due to their ability to provide high-resolution aerial imagery for monitoring plant health and growth. Different types of sensors available for measuring plant growth and environmental parameters such as temperature, humidity, light, soil moisture, and nutrients, and their potential application in horticulture. Use of drone technology in horticulture, including their ability to capture high-resolution aerial imagery for plant health monitoring and the potential for autonomous drone operations for crop scouting, spraying, and other management activities.

The Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani has taken initiatives to promote the digitalization of agriculture. The “Centre of Excellence for Digital Farming solutions for Enhancing Productivity by Robots, Drones and AGV’s (DFSRDA)” under Centre for Advanced Agricultural Science and Technology (CAAST) has been established under World Bank sponsored NAHEP of ICAR, New Delhi, Government of India, since 2019. The centre has been engaged in training PG students and faculty members about advances in digital technologies. The centre has established an advanced basic engineering hardware and software setup such as Mechatronics, CAD/CAM/CAE, 3-D Printers and Instrumentation Laboratories for Agri-bots, Agri-drones and Agri-AGVs, and a holistic model has been developed to raise the standard of current agricultural education system that has been facilitating more jobs and entrepreneurship development among the youth and on par with the global agriculture education standards.

Sensor-based management in horticulture and drone application has great potential to revolutionize the industry and contribute to sustainable food production. However, it requires careful consideration of the challenges and limitations associated with these technologies, as well as the development of appropriate data management and decision-making processes to effectively utilize the data obtained.

1.1.3 Precision in mechanisation of horticultural crops

K.K. Singh
VC, SUPUA&T, Meerut

2.1 Plenary Lecture

2.1.1 Biotechnological approaches for precision breeding in horticultural crops

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Horticulture is one of the oldest agricultural practices which play a major role in economic prosperity throughout the world. Horticultural crops comprise mainly fruits, vegetables, medicinal, aromatic, and ornamental plants. India is the second-largest producer of horticultural produce, contributing about 12% of the global fruit and vegetable production and accounts for 30% of India's agricultural GDP. However, the changing environmental conditions mainly the occurrence of unexpected stress events such as drought, floods, salinity, high temperature,chilling or frost, high CO_2, radiation stress and emerging pests and pathogens continue to pose significant challenges to horticulture sector. The major challenge faced by the researchers is to feed the expanding population in light of the rapidly changing environmental conditions. Conventional plant breeding relies on development of varieties to address the constraints by utilizing the existing gene pool. The challenge of conventional plant breeding resides in improving all of the traits of interest simultaneously, a task made more difficult by the physical linkage between genes in the chromosomes. Recent genomic technologies have expedited breeding and trait development for increased environmental resilience and productivity due to greater understanding of mechanisms underlying the yields gain in variable environments. With the advent of molecular markers, considerable advance was made in increasing the efficiency of breeding, leading to marker assisted selection (MAS) or marker assisted breeding (MAB). Next-generation sequencing (NGS) technology allows researchers to decipher entire genomes and identify the genotypes possessing the desirable candidate genes to be used for developing varieties with higher yield and other novel traits. Genomic selection (GS) which combines the precision phenotyping and genome-wide sequencing to calculate the genomic estimated breeding values (GEBVs) to identify offspring that can serve as parents. GSis used to accelerate breeding for yield potential, which is frequently considered as the most difficult trait for marker-assisted selection. Rapid advances were made in the field of molecular biology by introducing genes of interest with known functions; however, due to growing regulatory concerns of these genetically modified crops, genome-editing tools have emerged as a new biotechnological intervention to modify crop genomes without traces of foreign gene introduction in a wide variety of plants. Clustered regularly interspaced short palindromic repeats (CRISPR)/CRISPR-associated 9 (Cas9) based systems are the widely used genome editing tools.Genome editing in a horticultural crop was first attempted in 2013 using TALENs in *Brassica oleracea;* in subsequent year's tomato and potato received much attention for genome editing targeting the stress and developmental related genes. Because of its low cost, simplicity, and high efficiency, the CRISPR-Cas system has become the most widely used system for plant genome editing. Classical methods for breeding for heterosis in cross-pollinated crops make it possible to achieve homozygosity only after 6–7 years of inbreeding. Doubled haploid technology revolutionized the time required to achieve genome fixation for many crop species. Haploids can now be induced in vivo by manipulating the centromere-specific histone 3 variant, CENH3, targeting genes like CENH3 and sperm-specific phospholipase, MATRILINEAL (MTL). Lastly, genome editing alone will not address the issues of agricultural productivity and sustainability Conventional breeding blended with modern biotechnological tools like combined with genomic selection and high-throughput phenotyping can help breeder and research community to meet the ever-increasing food demand under ever changing environmental conditions.

2.1.2 Agricultural (*Kisan*) drones: transforming India's agriculture, opportunities for leaf frogging

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Rapid evolution of autonomous drone technology offers a new tool for making agricultural practices more efficient, equitable and less damaging to the environment at a time when agriculture progress is critical to achieve the targets of sustainable development goals set by the global community. Autonomous drones can replace several farming tasks previously performed by satellites, manned aerial aircraft, ground-based spray equipment, and manual labour. From a business perspective, for small and marginal farmers who account for 85% of total agricultural land holdings in India, a key implication of *Kisan* drones lies in utilising this smart disruptive precision tool as a solution to ease resource and productivity constraints such as climatic risk, soil degradation, water scarcity, inefficient and indiscriminate fertilizer and agrochemical use, labour shortages and rising operational and production costs. Furthermore, for farmers, FPOs, crop consultants etc. who do not currently practice smart farming, field application of *Kisan* drones also becomes a gateway for future adoption of smart farming capabilities, delivered more affordably by autonomous drone technology.

Adoption of kisan drones in India may impact several aspects, such as: **(i)Drone-as-a-service (DaaS)** to farmers is expected to grow to over Rs. 30,000 crore (USD 3.9 billion) in next three years and generate over 5.0 lakh jobs; **(ii)Adaptability -** Feasible, viable and cost-effective option for agrochemical spraying in diverse smallholder fragmented and irregular field plots, hard to walk wet muddy rice fields, hilly and mountain terrains, and speciality crops (tea, coffee etc) on steep slopes; **(iii) Precision farming -** Drones allow farmers to constantly monitor crop condition in real time (remote sensing) to rapidly find inter- and intra-field variability to provide precise guidance to farmers on optimum spot application of agri-inputs; **(iv)Input Application and use efficiency -** Precise application of agrochemicals using drones enables timely and effective pest control with 4.3 to 15% higher control efficiency and an estimated agrochemical saving of 20 to 93% over manual knapsack spray in diverse crops owing to improved spray coverage, droplet density and droplet deposition uniformity; **(v)Higher productivity** - Spraying agrochemicals using autonomous drones enhances field capacity (13 to 18 times more coverage per unit time depending on the crop), improved pesticide use efficiency (12.6 to 45.3%), higher labour productivity (3 – 4 times), economical, rapid and effective application in response to sudden pest outbreaks, meagre water use (92 to 95% lower) for agrochemical spraying, higher crop yields (3.7 to 22.5%), cost effective ness, enhanced profits, negligible pesticide residues, food safety, and ecosystem sustainability, and **(vi)** Human safety – reduced risk of health hazard owing to 2 – 3 orders of magnitude less dermal exposure of operators to pesticides and lower postural discomfort. Finally, it is concluded that adoption of drones in agri-horticultural crops in the country opens tremendous opportunities for drone manufacturers, drone service providers, scientists, plant protection industry, unemployed youth, farm consultants, farmer producer organisations, farmer cooperatives and small & marginal farmers.

2.1.3 Precision breeding for set goal with special reference to horticulture

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Dryland agriculture is increasingly challenged by soil degradation, climate change, and low profitability with limited technological choices to change the situation. Diversification is one of the key components to make drylands profitable while conserving natural resources. Dryland horticulture has proven to be most successful in terms of yield maximization and resource conservation at the same time brings profits to farmers. However, there is need for more innovative approaches like precision horticulture to make this initiative more profitable and sustainable. Precision horticulture is an information-based management strategy that relies on collecting site-specific or plant-specific data. These data can be converted to useful information that helps growers make informed management decisions. Precision horticulture can benefit growers because of the high value of their products and the large amounts of crop inputs used in producing horticultural crops. Any improvement in reducing production costs can greatly increase profit for producers. Also, the optimal use of crop inputs in precision horticulture can potentially reduce the environmental impact of horticultural crop production. Sensor systems that collect data on weather, soil and plant-specific data cost-effectively play a key role in practicing precision horticulture.

Precision breeding techniques are a broad set of technologies that provide additional tools to introduce genetic variation into the genome and these techniques. These techniques drive new improvements to agriculture and a broad range of solutions to help farmers deliver better harvests. Within the context of conventional breeding, most of these techniques pose no unique safety issues. For e.g., application of precision breeding technology to grapevine cultivar development, in which only genetic fragments from sexually compatible "parents" are utilized, is now attainable and is a logical extension of conventional breeding. A precision breeding approach is more predictable, much less disruptive, and more efficient than that of conventional breeding because only specific traits are transferred, and key obstacles are avoided. However, as with all new varieties, substantial field evaluation, as is the norm for conventionally bred crops, will be required to determine whether precision bred versions of elite cultivars will possess desirable attributes and/or otherwise be useful. Genome editing is one of the successful methods deployed in precision breeding where genes are known for specific traits of importance, and precise editing is feasible to develop improved cultivars suiting the commercial needs. ICRISAT is working on a number of crops using genome editing to increase the striga resistance, to increase the shelf-life, to reduce HCN content in forages, herbicide tolerance, among others.

2.1.4 Dynamics of greenhouse technology for horticultural crops

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Greenhouse Technology or Protected Cultivation has become increasingly popular in horticultural crop production in the last two and half decade due to its ability to provide controlled or better environment that can tailored to the crop specific requirements in different regions of the World. Area under greenhouse technology has also increased in India in the last two decades from less than 5000 hectares in the year 2000 to more than 160000 hectares during the year 2022. Greenhouses enable Horticultural producers to grow crops in regions with favourable climatic conditions, extend the growing season and period, and produce high quality, high value crops that meet market demands.

Greenhouse technology offers many advantages over traditional open field production system by providing better/controlled temperature, humidity, light and other environmental factors, providing an optional growing environment for different horticultural crops. It also provides protection against viruses, pests and diseases with minimum use of chemicals for improving crop yields and quality. Greenhouses can extend the growing season by providing a optimum and stable environment, enabling growers to grow crops year round for harvesting higher yields and improved quality.

There are several types of greenhouses being used for production of horticultural crops in different parts of the World, viz., Glasshouses, Climate Controlled Greenhouses (equipped with cooling and heating systems), Semi-climate Controlled Greenhouses (equipped with only one device either heating or cooling systems as per regional requirements), Naturally Ventilated Greenhouses and High Tunnels, etc. Now-a-days, open roof type and retractable type multi-span greenhouses are also being used by growers for production of crops like black cherry, etc.

In India, mostly naturally ventilated greenhouses are being used for cultivation of high value vegetable crops, ornamental crop like cut flower roses, gerbera, carnation, livlium and limited fruit crop like strawberry and papaya, etc. Semi-climate Controlled greenhouses equipped with pad and fan systems for cooling during the peak summer season are mostly being used for production of planting material or seedlings of different horticultural crops.

There are several key factors responsible for success of the greenhouse technology viz., size selection, design and construction of the structure, selection of crop and variety, management of the crop during the entire crop cycle, management and maintenance of the greenhouse and marketing of the produce on optimum price, etc. The success of the greenhouse technology also depends upon its level of adoption. Cluster approach of adoption of the technology has always been found successful in different regions of the World. In India, the most successful model of adoption of this technology is at Village Basedi, 15 km away from the Jobner Campus of Sri Karan Narendra Agriculture University, Jobner. In this region, there is no ground water available, and the entire greenhouse technology is clubbed with 100% rain water harvesting and its use in production system and use of solar power for running the irrigation or fertigation system. There are around 500 naturally ventilated greenhouses in the Village and each greenhouse is upto the size of 4000 m^2 (one acre) and mostly each farmer is having 5-10 acres of greenhouses and presently they are growing only two crops of Parthenocarpic Cucumber in production cycle of one year. Most of the greenhouse growers are highly progressive using all latest knowledge available in the field of greenhouse technology. Sri Karan Narendra Agriculture University, Jobner is always keen to further improve the production system of this Village.

2.1.5 Precision horticulture through geomatics

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Continuous increasing cost of inputs like seed, fertilizer, herbicide and pesticide coupled with critical resource- water becoming scarce year after year, it has become essential to go for precise application of inputs. This precision has to be both in time and space domain. To guide the precision in application of nutrient and water the most important information needed is knowing the availability and/or depletion at nutrient and water at specific location in the field. Timely action is needed to prevent deterioration in the quality of produce as well as the volume of production. One possible way is to monitor the crop growth throughout the growing period employing devices that can detect nutrient and water status in plant. Spectral bands in red, near infrared, shortwave infrared and thermal infrared are known to capture changing water and nutrient status in plant canopy. Recording the spectral response of objects is known as remote sensing. Remote sensing devices can be handheld camera to sensors placed onboard drone, aircraft or satellites. High spatial resolution multispectral remote sensing image acquired at frequent interval could be useful in such monitoring.

An example of banana crop in Jalgaon district Maharashtra state is discussed. Multispectral images of 10m spatial resolution, acquired at 5-days interval are available with open access and free of cost. Attempt has been made to identify individual banana fields in a part of Jalgaon district, Maharashtra. Normalised Difference Vegetation Index (NDVI) images generated with the reflectance in Red and Near Infrared bands have been used. Statistical analysis of temporal NDVI data for banana fields has been done. Field data like date of planting, spacing, fertilizer basal dose as well as nutrient and water applied through fertigation was collected from the farmers. Analysis of NDVI statistics has shown that most of the banana fields attained high NDVI indicating good crop growth. However, within field variability in crop status as measured through standard deviation in the NDVI of a field has shown varying levels. There were fields with no variability in NDVI indicating uniformly high quality of crop. At the same time there were several fields with 10 percent variability and even 20 percent variability in NDVI. It is indicative of within field non-uniformity in crop performance. Next step will be to map NDVI of individual pixels and geotag the low NDVI pixels, analyse the plant for water and nutrient content. Such analyses will enable developing remote sensing based method for guiding fertigation.

3.1 Plenary Lecture

3.1.1 Precision production techniques for improving the productivity and quality of papaya

N. Kumar
Former VC, TNAU, Coimbatore

3.1.2 Precision farming for sustainable and future smart horticulture

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Horticulture in India contributes significantly in terms of nutritional security and economy, contributing thirty three per cent of the agriculture Gross Domestic Product. The rising demand of horticultural produce due to population growth, high nutritional value and export profit poses the challenge for its enhanced productivity. Use of advanced technology like precision farming can play a major role in transforming horticulture farming to more sustainable, efficient, profitable and eco-friendly leading towards the Agriculture 4.0 revolution. Use of precision farming technologies like remote sensing, information technology, artificial intelligence, big data analytics, automation, advanced robotics and decision-support in horticulture enables the farmers to get higher yields through the optimum use of resources. According to an estimate by the World Economic Forum, if 15-25% of farms adopted precision farming by 2030, global yield could be increased by 10-15% with 10% reduction in greenhouse gas emissions and 20% in water use. Implementation of precision horticulture technologies relies on sensors and systems that collect weather, soil and plant-specific data leading to optimal use of inputs that can potentially reduce production costs resulting in increased profits and also reduced environmental effect on production.

These tools are used for early biotic and abiotic stress detection, canopy management, agro- inputs (optimum fertilizer and water use), yield estimation and quality management. In recent years, the focus has been on the smart orchard concept, fruit and vegetable harvest automation, post-harvest handling and to accelerate technology innovation and adoption. However, there is a need to focus on developing low cost site-specific technologies and strategies for small fields which are economically viable and easy to adopt by small farmers. Also, there is a need to protect data privacy. The use of precision horticulture farming can significantly increase productivity, quality and enable the Indian farmers to become economically viable in a globally competitive horticultural market.

3.1.3 Precision horticulture in Andhra Pradesh - A prospective

Chiranjivi Chaudhary
Secretary to Government, Andhra Pradesh

3.1.4 New Education Policy (NEP-2020) and precision agriculture: accomplishments, prospects and challenges

Punyavrat Suvimalendu Pandey[1] & Vikas Kr Rai[2]
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Agriculture sector is the mainstay of the Indian economy, it contributes about 20.2 percent gross domestic product (GDP) increasing from 19.9 percent recorded in 2020-21, and more importantly, about half of India's population is significantly dependent on agriculture and allied activities for their livelihood. The contribution of agricultural sector to GDP has continued to decline over the years, while that of other sectors, particularly services has increased. Even after over seven decades of planning since independence, most farmers still face problems of poor production and poor returns. According to Indian Council for Agricultural Research (ICAR) the demand for food grain would increase to 345 million tonnes by 2030.The agricultural education system in India has played a crucial role in strengthening food security in the country. Now days, the agriculture sector faces numerous challenges, such as climate change, water scarcity, soil degradation, and low productivity. To address these challenges and promote sustainable agriculture practices, there is a need for a well-trained and skilled workforce in the agriculture sector. The New Education Policy (NEP) 2020 recognizes various gaps and aims to provide a more holistic and multidisciplinary approach to agricultural education. The NEP emphasizes the integration of vocational education and training into the mainstream education system and encourages the development of skills relevant to the 21stcentury, such as precision agriculture, digital agriculture, and entrepreneurship. This will enable students to gain practical knowledge and skills that are essential for success in the agriculture sector. The NEP also recognizes the blending of tradition, talent, technology and trade including potential of online learning platforms in enhancing access to quality education, especially in remote areas. This can be leveraged to provide training and education in precision and digital agriculture to a wider audience. Modernization of agriculture and the use of precision technologies have resulted new concepts to emerge such as artificial intelligence (AI) and digital farming with the help of digital education. In this regard, government has started ICAR-Network Programme on Precision Agriculture (ICAR-NePPA) and Digital Agriculture Mission for 2021-2025. The main purpose of the mission is to support and accelerate initiatives based on new technologies, including AI, block chain, remote sensing, and GIS technology along with utilization of robots and drones in agriculture practices. Therefore, in conclusion, the NEP 2020 can play a crucial role in promoting precision and digital agriculture by providing students with the necessary skills and knowledge and leveraging digital technologies for education and training.

3.1.5 Approaoches for the secondary agricutlure for efficient utilization of resources

Ashok Dalwai, IAS
CEO, NRAA, New Delhi

TECHNICAL SESSION-2

TECHNOLOGICAL CHALLENGES AND APPROACHES FOR PRECISION HORTICULTURE

2.1 Keynote Lecture

2.1.1 Precision system in horticulture for resilience and sustainability

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Regenerative horticulture is a holistic approach of conservation and rehabilitation of farm management system which focuses on topsoil regeneration, increasing biodiversity, improving the water cycle, enhancing enhancing ecosystem services, supporting bio-sequestration, increasing resilience to climate change and strengthening the health and vitality of farm soil. In the Precision management system practices are adopted on the principle of observe, measure and respond. Thus the system becomes effective in improving soil health by rebuilding soil organic matter and restoring degraded soil biodiversity, crop resilience and nutrient density. This results in increased biodiversity both above and below the soil surface, as well as increased water holding capacity and carbon sequestration at greater depths, lowering climate-damaging CO_2 levels in the atmosphere. Inoculating soils with compost or compost extracts to restore soil microbial community population, structure, and functionality, as well as restoring soil system energy (compounds as exudates) through full-time planting of multiple crop intercrop plantings, multi-species cover crops, and borders planted for bee habitat and other beneficial insects, are all important in increasing biological ecosystem diversity. Growing a diverse crop mix protects against pests and diseases, provides a diversified income stream and habitats for more pollinators, and improves soil health. As soil health improves, input requirements may decrease, and crop yields may increase as soils are more resilient against extreme weather and harbor fewer pests and pathogens. Regenerative agriculture, captures the atmospheric carbon dioxide by growing plants that move that carbon dioxide into the soil, is pretty nearly the only currently-functioning technology available for drawing down greenhouse gases that are already in the atmosphere, mostly through the cultivation and nurturing of forests and permanent perennial pastures and grasslands. Principals behind regenerative agriculture are 1) enhancing and improving soil health, 2) optimization of resource management, 3) alleviation of climate change, and 4) improvement water quality and availability. A survey of organic and conventional farms in Europe found that on the whole, species across several taxa were higher in richness and/or abundance on organic farms compared to conventional ones, especially species whose populations have been demonstrably harmed as a direct result of conventional agriculture. Although, concept of regenerative agriculture started in 1980 but it got focus in 2010, and more so recently. Since February 2021, the regenerative agriculture market gained attraction after it mention by Joe Biden's Secretary made a reference to it during his Senate Confirmation hearing. After that, national and international organisations have started working with focus on regenerative agriculture. But many scientists based on evidences do not agree that it will mitigate climate change.

Perennial horticulture, which includes fruits trees, plantations, and some spices crops, does not require replanting each year as they exhibit long root systems that can retain water, improve soil porosity, sequester more carbon, and improve soil health, thereby improving ecological, animal, and human health through improved micro-nutrients availability and better dietary balances. Planting native-to-a-region crops, plays an important role in improving biodiversity and are utilised as the main cash crop, incorporated into conservation buffers, or used as cover crops. Diversity and perenniality are the essential components of regenerative agriculture, therefore, promoting perennial horticulture can help build healthy soils, restore clean surface and groundwater, and enhance the resilience of our food system. As a result, in order to counteract climate change, it is critical to support an agriculture system that is both ecologically and economically viable. However, India's current economic and political structures are geared toward monocultural production, and for this type of perennial horticulture to prosper, appropriate socio-political and economic systems must be in place to support such system. There are various examples in horticultural crops that with effective reduce management soil heath can be improved and crops can be grown with minimum outside inputs. The paper discusses in detail.

2.1.2 Precision farming in horticulture – an experience from telangana

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Precision farming is a management concept based on observation and response to intra-field variations. New technologies such as Global Positioning Systems (GPS), sensors, satellite/aerial images and Geographical Information Systems (GIS) are utilized to assess and analyze variations in agricultural and horticultural production. Adoption of the precision farming technologies like drip/sprinkler irrigation, protected cultivation (greenhouse, low tunnels and shade net house cultivation), plastic mulching will aims at increasing productivity, decreasing production costs and minimizing the environmental impact of farming. Studies conducted in precision farming techniques in different horticultural crops of SKLTSHU reported that higher yields & B:C ratio with precise use of limited resources. Few among them are drip irrigation once in a day at 80% PE has recorded highest rhizome yield of turmeric (38.32 kg/plot) followed by drip irrigation once in 2 days at 80% PE (37.21 kg/plot). Application of drip irrigation at 0.9 bar and black polythene mulch has increased tomato yield (432.3q/ha) by 25% higher compared to flood irrigation (349.0 q/ha). Stage wise fertigation of okra scheduled with 20% at germination, 50% at vegetative stage and 30% at reproductive stage of RDF (200:100:100 kg/ha) recorded highest yield (113.31 q/ha). Likewise in broccoli the highest B:C ratio (1:4.70) was observed in 80% RDF (160-100-100 NPK kg/ha) through drip irrigation, water soluble fertilizers 12-61-0 - MAP (41 kg/ha) & 13-0-46 –KNO_3 (225 kg/ha) in 17 splits at 5 days interval. Hence, Precision farming in horticulture is expected to become much more widespread in the coming years symbolizing a balance between traditional knowledge, information management and innovative technologies.

2.1.3 Advances in precision horticulture in gujarat

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The horticulture sector in India is providing food security, nutritional security & health security in the Country. The role of horticulture is become even more enhanced in increasing farmer's income and making the farmers self-reliant. The optimum yield and quality of horticulture produce require optimum inputs like water, fertilizer, insecticides and pesticides. Presently, most of the farmers apply all these inputs in approximate quantity based on their experience. This practice leads to wastage of costly inputs leading to increase in cost of cultivation as well as cause negative impact on water quality, soil health and environment. The over-exploitation of natural resources has to be minimized specially for climate resilience sustainable horticulture production. Precision farming is a modern technique that helps to improve the overall productivity of crops by making precise predictions regarding plant and soil needs, monitoring growth, and weather conditions. This article is aimed to discuss various components of precision horticulture such as enhancing crop water productivity through automation, pulses, deficit and aerated irrigation, Variable Rate Technology (VRT), nutrient expert system, weed mapping, variable spraying as well as application of remote sensing, geographical information system, artificial intelligence, robotics and drone including automation in harvesting and post harvesting. The various aspects of research in precision horticulture in Gujarat are also highlighted, *e.g.* optimum scheduling of fertigation for precise irrigation and fertilizer application in various horticulture crops in various splits recommended by SAUs of Gujaratwere reported the savings of 30 to 40 % water, 20-60% of fertilizer and 8-41% increase in yields. Along with these, constraints and future prospects of precision horticulture are discussed.

2.1.4 Precision horticulture in himalayas -challenges and ppportunities

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The Indian Himalayan region is spread across 13 Indian States/Union Territories (namely Jammu and Kashmir, Ladakh, Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Assam and West Bengal), stretching across 2500 km. Nearly 50 million people reside in this region, which is characterized by a diverse demographic, and versatile economic, environmental, social and political systems. The region is known as water tower as many major river systems are originated from the region. The area is also of strategic importance since it is neighbouring to the countries like China/ Tibet, Pakistan, Afghanistan, Nepal, Bhutan and Myanmar. The Himalayan region is also hot spot for many flora and fauna. It is considered one of the major hot spots of plant diversity in India. A large number of wild edible plants are grown since time immemorial in such areas. Wild fruit plants are playing crucial role in the livelihood and nutritional security of the local population in hilly regions. These wild resources have tremendous potential to mitigate the challenges of climate

change, irrigation water crises, and utilization of poor degraded lands. Such plants have excellent ability to tolerate both biotic and abiotic stresses. Various parts of these plants are used in traditional system of medicines, like Ayurveda and Siddha, etc., for curing of numerous chronic diseases and disorders. Enormous ethno-botanical knowledge is available on these plants with the society, which is now eroding day by day. Vagaries of weather/ adverse climate condition, poor soil, crisis of Irrigation water and limitations of communication are the major challenges in the progress/ development of horticulture in the region.

Using local knowledge systems and local resources for designing and development of local low cost green houses have played major role in revolutionizing the protected cultivation in many states of the region. This has helped in enhancing the growing season, conservation of diversity, nursery management & growing off season/ rare crops. Mulching, use of plastics and water conservation techniques are other approach to boost the production and productivity in the region. Limited infestation of pests/ insects and diseases offer opportunities for organic & toxin free cultivations of crops. The region also has tremendous potentials for disease free quality seed production of flowers & vegetables, especially of European types to curb the import of seeds and planting material.

Defence Research & Development Organisation (DRDO) has also done extensive survey and studies on underutilized fruit crops of Himalayan regions of India, with the aim to identify the potential genotypes, evaluation and conservation of valuable genetic diversity, scientific propagation, cultivation and utilization of these resources to develop future fruits of Himalayas. Based on the studies, DRDO has identified *Pyrus pashia* (Mehal), *Myrica esculenta* (Kaphal), *Rubus ellepticus* (Hisalu), *Berberis aristata* (Kilmora), *Rhododendron arboreum* (Buransh), *Punica granatum* (Darim), *Hippophae* spp (Seabuckthorn), *Ficus palmata* (Bedu), *Cratagus crenulata* (Hawthorn) etc. as potential crops for future having nutritive and nutraceutical properties.

Based on initial studies of these crops, techniques were standardized for their scientific propagation to conserve the diversity and boost the availability of quality planting material for commercial cultivation. Field gene banks have been established in different zones of Himalayan regions to conserve valuable diversity and support the future breeding programme. Efforts have also been made to develop methods for their commercial cultivation. In order to minimize the wastage of perishable fruits growing in remote hilly regions, value addition technologies have been developed. Initiatives have also been undertaken to patent and commercialize the processing methods where raw materials is plenty available. Developed technologies have been transferred to private vendors which have created awareness in local population about their economic values besides generating employment. The need of the hour is to provide policy support like setting up modern nurseries and boost the plantation by adding these crops in government schemes. Also support is requires in establishing the primary centers in remote hilly regions to tap the resources and generate entrepreneurship among the local youth.

2.1.5 Urban horticulture – a truly multidisciplinary Enterprise

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Urban farming has gained popularity and innovation in recent years, due to factors like population growth, urbanization, climate change, and food insecurity. It can provide fresh, local, and healthy food to urban residents. It can also help in reducing food waste, greenhouse gas emissions, and transportation costs, while creating jobs, income, and social benefits for urban farmers and consumers. Urban farms also provide unique opportunities for individuals, especially those living in cities, to get actively involved with ecological citizenship. By reconnecting with food production and nature, urban agriculture, urban farming, or urban gardening is the practice of cultivating, processing, and distributing food in or around urban areas. It encompasses a complex and diverse mix of food production activities, including fisheries and forestry. The term also applies to urban area activities of animal husbandry, aquaculture, beekeeping, and horticulture. These activities occur in peri-urban areas as well, although peri-urban agriculture may have different characteristics. Urban farming faces some challenges, such as land availability, zoning regulations, water quality, pests, and market competition, but it also offers many opportunities and solutions for sustainable and resilient urban food systems.

The key technologies employed in urban horticulture include soil less media and micro-irrigation technology without which urban farming will not sustain. Rain water harvesting, protected cultivation technologies play important supportive role. Automation and remote monitoring are becoming popular technologies in urban farming as economics is not generally considered as in case of regular farming practices. The present paper aims at presenting the role and results of adoption of these technologies at different locations, however a few systematic studies on the subject considering all technologies wholistically need to be encouraged.

2.1.6 Precision production systems through architectural management in temperate fruits

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The agro climatic conditions in the Himalayan region are highly conducive for growing of temperate fruit crops like apple, pear, peach, plum, apricot, almond, walnut, kiwi fruit and other minor nuts and berries. However, the productivity of these crops is continuing to be low as compare to their potential. Based on the numerous research investigations it has been found that fruiting potential of the tree is largely governed by its architecture, canopy density and photosynthetic efficiency. Canopy architecture in fruit crops modulates the size, shape and orientation of branches and trees leading to development of fruits having potential size, shape, colour and secondary metabolites to harvest maximum number with uniform size and quality fruits. Canopy design and shape influence light interception and distribution within canopy which includes a range of techniques to alter the position and the amount of leaves, shoots and fruit in space through training, pruning (dormant, summer and root pruning), branch orientation (bending), scoring, girdling, bark inversion, selection of proper rootstock, use of plant growth regulators, appropriate use of fertilizers, deficit irrigation, use of genetically engineered plants with altered architectural characters etc. that would help in maintaining the ideal tree canopies.

Architectural engineering manipulates the plant design precisely for optimum utilization of resources augmented with suitability for mechanization. Plants are designed in way to improve their morphology (tree shape, scaffold orientation and specific leaf area), architecture (fewer growing shoots, non-competitive shoots and proportion of flower clusters) and phenology (precocity and reduced number of days at full bloom).Modern two-dimensional architectural designs like Tall Spindle System, Espalier System and Tatura Trellis form designer plants with maximum potential for harvesting solar energy and its conversion to sink. The specialized designs like slender pyramid, spindle bush, slender spindle, super spindle, tall spindle, dwarf pyramid, head and spread, vertical axis, solaxe, espalier, cordon, multiple leader bush, palmette, Y-trellis etc. in apple, pear, cherry and peach resulted in at least 4-5 times more productivity. At ICAR-CITH, Srinagar, productivity of 55-66 t ha^{-1} was recorded in apple with tall spindle, vertical axis, espalier and cordon system of training system and 50-55 t ha^{-1} recorded in peach from V shape tatura trellis system. Through different pruning technique we can greatly reduce tree volume and increase light interception and distribution. Use of dwarfing rootstock reduced tree size and increasing the partitioning of dry matter to fruit production results in precocious flowering. Feathering in nursery plant can be induced by pinching, girdling, scoring, and by use of chemicals like BA, BA + GA_{4+7}. Canopy design with plant growth management through mechanical pruning and application of plant growth hormones are very effective for enhancing yield and improving fruit quality of temperate fruit crops. Genome editing and genetic engineering can alter plant architecture in apple, peach, plum, kiwifruit to make them suitable for novel production systemsby introducing or manipulating *rol*, tumour-inducing (T)-DNA, *phy*A, FT1 gene, Co-gene *etc.*

2.2 Oral Presentation

2.2.1 Regulation of bulbing and flowering time and its indeterminate development in short day onion

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Allium cepa L. (common onion) is one of the leading vegetable/spice crops grown and consumed all around the globe. Its distinct taste and medicinal values gives it additional dietary importance. India ranks first in terms of cultivation however; Maharashtra is the leading state within India. Basically it's a biennial crop; bulbing and flowering are the two important but antagonistic and sensitive phenomena of its life cycle. The commercial gain of the farmer is over all depends on the success of these two phases and interestingly, these are governed by the same set of genes. The phosphatidylethanolamine-binding protein (PEBP) gene family plays a crucial role to control these phenomena in response to environmental stimuli. This family is made of six genes in model plant Arabidopsis however *FLOWERING LOCUS T* (FT) and *TERMINAL FLOWER 1* (*TFL1*) regulate flowering antagonistically, *FT* act as inducer whereas *TFL1* act as the repressor of flowering. In this study, we focused on *FT*/*TFL1* like genes involved in the regulation bulbing as well as flowering in short day type onions, namely JISL5 and JV12. We identified 11 *FT* like and two *TFL1* like genes that are at least present in the onion genome. *In-silico* analysis and expressional behavior of these genes were observed at different life stages as well in different tissues to know the probable conserved role of these genes in bulbing and flowering of onion. Functionality of the same genes was also studied in wild-type and specific mutant of model plant *Arabidopsisthaliana*. *AcFT1* expression is induced at the time of bulb initiation whereas *AcFT4* expresses during vegetative development. *AcFT2* expression in vernalized bulb of JV12 and the leaf tissues during flowering phase of JISL5 indicates its role in flowering. *AcTFL1* predominant expression in the meristematic tissues during bulbing and flowering suggest that it is involved in bulb and umbel development. In Arabidopsis, *AcFT1* induces early flowering in wild-type and corrects late flowering defect in mutant whereas *AcTFL1* is able to delay flowering in wild-type and complement early and terminal flowering defect of its mutant. The cumulative analysis suggests that, *AcFTs* plays a crucial role in deciding the bulbing and flowering time whereas *AcTFL1* is involved in its indeterminate development.

2.2.2 Production of potato minituber using aeroponics technology: An emerging food growing system in sustainable agriculture for food security

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Precision farming is a management concept for agriculture based on continuous observations, measurements and responses to data from fields, coupled with the precise application of resources. It gives a nudge to climate-smart farming and helps to utilize resources effectively without polluting the environment and will result in sustainable agriculture and sustainable development.Hence precision agriculture is about doing the right thing, in the right place, in the right way, at the right time.One of the popular methods of precision farming includes aeroponics. Aeroponic cultivation is an alternative technology of soilless culture for effectively adapting to the areas of the world where soil and water are in critical condition. It reduced water usage and increased yields as compared to other controlled environment agricultural techniques. The lightweight trays from aeroponics also make possible to utilize vertical space. It is a modern technology for the production of pre-basic seed potatoes (minitubers). In the aeroponic cultivation system, the roots and underground stems of potato plants are placed in module, suspended in the air and supplied with nutrient solution dispersed in the form of fine fog particles (30–100 microns). Minitubers produced in an aeroponic system are well-protected from pests and soil-borne diseases. These systems enable the production of a high number of minitubers per plant during the growing period, which is usually prolonged for one to two months. Depending on cultivar and aeroponic system, potato plants can produce 30–170 minitubers per production period. Besides, successive harvesting allows minitubers to reach their desired and uniform size. Due to the recirculation of nutrient solution, minimal environmental pollution and efficient usage of space, aeroponic technology enables the production of potato minitubers, as well as cultivation of other vegetable and ornamental plants, in an environmentally friendly manner.

2.2.3 Study of phenotypic and biochemical characters of mango (*Mangifera indica* L.) genotypes in Bihar

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Mango (*Mangifera indica* L.) is a dicotyledonous plant that belongs to the Sapindalesorder, which has 73 genera and roughly 830 species. Because performance changes with climate,it is extremely heterozygous, resulting in a high level of genetic variety. The intendedimprovement in ideal plant type needs greater attention for making its cultivation more profitableby increasing production with low inputs. Utilization of conserved germplasm in breedingprogrammes necessitates precise information on

genetic relationships among cultivars, as well asinformation on genetic distance between cultivars, which will aid in avoiding duplicates, clearingnomenclature ambiguity, broadening the genetic base of the core collections, and ultimatelypreserving the valuable diversity. The numbers of treatments were twenty five and samples werecollected from three different directions from each single plant for their analysis.A perusal the data indicates that there was asignificant difference in case of sex ratio of different mango genotypes. Highest sex ratio (31.83)was found in G-22 followed by G-11 (22.08) while lowest sex ratio (4.76) was recorded in G-03followed by G-06 (4.79). The maximum flowering intensity per cent (80.50%) was recorded inG-22 and minimum (29.00%) was found in G-31, the maximum fruit retention per panicle(4.00) was observed in G-18 followed by G-12. maximum peel weight (60.33 g) was noticed inG-44. Genotype G-44 produced highest stone weight (54.00 g) and the genotype G-02 producedlowest stone weight (21.33 g). Maximum pulp weight (252.83 g) in G-44 and minimum pulpweight (43.17 g) was recorded in G-22. The present study, TSS content significantly varied from 11.29^0 to 20.55^0.The maximum TSS content (20.55^0) was recorded in G-21 and minimum TSS content (11.29^0) observed in G-37.The maximum total sugar(13.90 %) was recorded in G-21 and minimum total sugar(7.27 %) was found in G-09.The maximum ascorbic acid (74.43 mg per 100 g) was recorded in G-21 and minimum ascorbic acid (34.23 mg per 100 g) was found in G-06. High estimates of the most of the characters under study indicated substantial variability in the existing germplasm to develop possible future pre-breeding lines of mango.

2.2.4 Assessment of salicylic acid impacts on frowth and yield attributes of banana under frought stress condition

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Field experiment was conducted at Banana Research Station, Jalgaon during 2017- 2021 with a view to alleviate negative effects of soil moisture deficit stress in banana through biochemical priming at critical phenological stages in banana. The experiment was laid out in Randomized block design (RBD) comprised of five treatments and four replications. The treatments were irrigated control, Soil moisture stress at floral primordial initiation stage (5 MAP),Foliar priming with acetyl salicylic acid (0.1mM) at floral primordial initiation stage (5 MAP)+ Soil moisture stress, Foliar priming with acetyl salicylic acid (0.1mM) at flowering + Soil moisture stress. Foliar priming was done two days before imposition of soil moisture stress when the soil moisture level is in field capacity. The plants were foliar primed with 0.1mM salicylic acid at floral primordial initiation stage and at flowering before imposition of soil moisture deficit stress by withholding irrigation till soil moisture reaches at -0.7 to 0.8 MPa or the relative water content (RWC) of 3rd leaf from top most reach 70- 75% and subsequently the stress was relieved by providing irrigation. The acetyl salicylic acid primed plants hadmore relative water content as compared to non-primed plants. At harvest, the bunch weight decreased in all the soil moisture stressed plants compared to control; however, the bunch weight recorded the lowest in Soil moisture stress at floral primordial initiation stage (5 MAP). The plants foliar primed with 0.1 mM salicylic acid at floral primordial initiation stage (5 MAP) and at flowering the bunch weight was more than non-primed drought imposed plants. Soil moisture stress at floral primordial initiation stage (5 MAP) the yield was decreased by 47.54 %. The finger length and girth was decreased by 17.02 % and 21.14% respectively.

2.2.5 Pollinators diversity and role of honeybees in aster seed production

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Aster, *Callistephus chinensis* (L.) is a seed propagated flowering annual crop extensively grown for loose flower production. Single and semi-double varieties are predominantly cross pollinated. Asters have a typical floral arrangement and bright petal colors that attract a large number of insects. Many factors affect pollinators' abundance in fields including chemical pesticides. Absence of pollinators especially bees is known to influence seed production in the aster crop. There is limited information available on basic ecological aspects of insect visiting aster flowers. We studied pollinator's diversity and foraging ecology of major pollinators in aster fields. We also studied the role of honeybees, *Apis florea* in enhancing seed vigour, germination (%) and quantity of aster seed production. Field experiments were conducted at the research farm of ICAR Directorate of Floriculture Research, Pune during 2021-2022. More than 29 species of insects were recorded visiting aster flowers during the day time. Among them, dwarf honey bee, *Apis florea* was found to be the most dominant species throughout the flowering season. The activity of flower visitors was significantly higher from 10.00AM to 2.00PM. The mean pollen load of *Apis florea* was found to be higher (0.38 mg), followed by *A. cerana indica* (0.22mg); *Ceratina hieroglyphica* (0.047mg); *Braunsapsis* sp. (0.04mg) and it was smallest in *Ceratina binghami* (0.02mg). The mean abundance of *Apis florea* (7.09 bees/m^2/min)was highest among other pollinators including *A. cerana indica* (2.42). Field studies on the role of bee pollination in quality and quantity of aster seed production revealed that the pollination by *Apis florea* increased seed yield from 1 kg/acre to 3.11 kg/acre and test weight from 2.12g to 2.84g. Also, it significantly increased germination (%) of seeds in aster variety Phule Ganesh Pink. Our findings indicated that the dwarf honey bee, *A. florea* is a major pollinator of aster and plays a vital role in aster seed production.

2.2.6 Influence of exogenous melatonin architectural transformation in mango seedling

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In plants, melatonin is mainly involved in germination, plant growth, rhizogenesis and senescence. It acts as a protector agent such as, improving photosynthesis, cell water retention, primary and secondary metabolism. In this aspect, to broadening the lore of melatonin behavioral study and instructive changes at structural level in mango seedlings this experiment was conducted at Bihar Agricultural University, Sabour. Different concentrations of melatonin (10 ppm and 20 ppm) were applied on one month old seedlings and their growth and structural changes were monitored at fourth month stage. Results showed that the mango seedlings treated with melatonin had significant structural changes as compared

to the control group. The seedlings treated with 20 ppm of melatonin exhibited significant decrease in root length, shoot height, nodal length than others. Moreover, 10 and 20 ppm treatment recorded remarkable increase in secondary roots (30% and 35.4%, respectively) and tertiary roots (33.2% and 52.4%, respectively) as compared to control. Besides, a significant decrease was observed in primary root length. A positive effect of melatonin was recorded on chlorophyll, nitrogen, potassium, and micronutrients availability in seedlings. Findings of this study suggested that the application of melatonin (10 and 20 ppm) had a positive influence on the structural transformation of mango seedlings. Therefore, melatonin could be used as a promising tool for improving root structure and enhancing the chlorophyll and nutrient availability in seedlings.

2.2.7 Understanding smart management system

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Smart Farming is an emerging concept that prioritises the integration of information and communication technology into the cyber-physical management cycle of farming. More robotics and artificial intelligence will likely be used in farming as a result of new technologies like the Internet of Things and cloud computing. Big Data, which refers to vast quantities of diverse data that can be collected, evaluated, and used for decision-making, encompasses this concept. The impact of Big Data applications in Smart Farming is not limited to the first stages of crop cultivation but rather permeates the entire food production and distribution system. The utilisation of big data has facilitated the provision of predictive insights in farming operations, enabled real-time operational decisions, and facilitated the redesign of business processes to establish innovative business models. Many researchers claim that the advent of Big Data will result in significant transformations in the distribution of roles and power dynamics among various stakeholders within contemporary food supply chain networks. The stakeholders' landscape presents an interesting dynamic involving influential technology corporations, venture capitalists, and frequently modest start-ups and emerging participants. Simultaneously, numerous public entities release open data, subject to the prerequisite of safeguarding individuals' privacy. Smart farming's future may play out along a spectrum between two possible scenarios: closed, proprietary systems in which the farmer is part of a highly integrated food supply chain, and open, collaborative systems in which the farmer and all other stakeholders in the chain network have the freedom to select their own technology and food production partners. The pivotal role in the competition between these scenarios will be played by the organisational integration of data and application infrastructures, including platforms and standards, as they continue to evolve. Organisational challenges pertaining to governance issues and viable business models for data sharing in various supply chain scenarios must be prioritised.

2.2.8 Effect of growth regulators and media on rooting of soft wood cuttings of guava

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The present investigation was conducted under shadenet condition during September 2021 to January 2022 at Research cum Demonstration Farm, college of Agriculture, Dhule, Maharashtra. The experiment was carried out in a Factorial randomized block design (FRBD) which comprised of two factors viz. rooting media (7 treatments)and growth regulators (5 treatments)making 35 treatment combination and were replicated three times. The growth regulator treatments IBA 2000 ppm (G 1), IBA 4000 ppm (G 2), Paclobutrazol 200 ppm (G 3), Paclobutrazol 400 ppm (G 4) and Keradix (G 5), whereas the rotting media treatments were Soil (sole)(M 1), Cocopeat (sole)(M 2), Soil + Cocopeat (1:1)(M 3), Soil + Perlite (1:1)(M 4), Soil + Peat-moss (1:1)(M 5), Soil + Po ting Mixture (1:1)(M 6), Soil + Vermicompost (1:1)(M 7). The results were encouraging indicating complementary interaction between rooting media and growth regulators. The interaction treatment T 17 (Soil+ Perlite + IBA-4000 ppm) recorded promising performance for all the characters studied. This treatment combination recorded maximum values for success percentage (83.13 %), number of leaves per cutting at 120 DAP (23.34), number of shoots at 120 DAP (3.87), number of primary roots per cutting (4.30), number of secondary roots (8.34), highest fresh weight of roots (4.3 g), highest dry weight of roots (0.97 g) and highest survival percentage (54.63 %). The results revealed importance of IBA at higher concentration i.e. 4000 ppm along with rooting media Soil+ Perlite (1:1) for better leaf, shoot and root characters and also survival of the soft wood cuttings in guava.

2.2.9 Remote sensing applications in potato characterization

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Potato is commonly consumed non-grain food in the world. Due to its importance in the food industry supply chain, potato has become a dominant crop in many countries. However, the continuously enhanced use of agricultural inputs could lead an environmental degradation. Moreover, the over and/ or inefficient use of water, fertilizers, pesticides and herbicides causes economic losses and negative impacts on the environment. To constantly and sustainably meet the increasing needs for potato production, reducing environmental losses with improved potato productivity, precision agricultural activities for potatoes is the solution. Precision agriculture has been gradually applied to monitor the crop growth status, generate auto-irrigation systems and disease detection systems in both developed and developing countries. Based on the interaction of electromagnetic radiation with soil and canopy reflectance, the remote sensing technique is considered as an effective tool in precision management for optimizing the decision-making process, which helps to improve profitable tuber yield, quality and minimize the negative impacts on the natural resources. Remote sensing has been utilized extensively in

precision agriculture for in-season crop growth monitoring and yield prediction. Vegetation indices calculated from remote sensing images are used to correlate to yield variability through statistical and machine learning models. Multi-temporal remote sensing monitoring across the growing seasons can uniquely offer insights into yield formation processes. Remote sensing systems, integrating advances in imaging, data processing and computing technologies thus have the potential to monitor the crop growth status and help make the decisions for crop management.

2.2.10 Influence of priming on germination of khirni seedlings (*Manilkara hexandra* L.)

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The field trial was conducted at the Nursery and Research Farm, Department of Horticulture, College of Agriculture, Dhule during 2021-22, to study the influence of priming on germination of khirni seedlings (*Manilkara hexandra* L.).The experiment was laid out in a Complete Randomized Block Design with ten treatments*viz.*, T_1 (GA_3 @ 50ppm), T_2 (GA*f* @ 75ppm), T_3 (GA_3 @ 100ppm), T_4 (GA_3 @ 200ppm), T_5 (NAA @ 100ppm), T_6 (KNO_3 @ 1%), T_7 (Cow urine @ 10%), T_8 (Cow urine 100%), T_9 (Cow dung slurry) and T_{10} Control (Distilled Water) with three replications.The treatment T_4(GA_3 @ 200ppm) resulted, the minimum days required for germination (30.33),however maximum number of seedlings germinate (42.33) at 15 days after sowingand germination percentage (84.67%) at 15 days after sowing observed in the treatment T_9 (cow dung slurry). Hence, it can be concluded that, the cow dung slurry were beneficial for increasing germination parametersas compared to other treatments under Khandesh region of Maharashtra.

TECHNICAL SESSION-3

TECHNOLOGICAL ADVANCEMENT IN PRECISION HORTICULTURE AND CHALLENGES FOR IMPLEMENTATION

3.1 Keynote Lectures

3.1.1 Horticulture for enhanced nutritional security - challenges and opportunities

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While India has crossed the hump relating to food security over the years, but under employment and disguised unemployment besides the challenge of nutritional security and farmers' distress continue. Currently, the agriculture sector is confronted with pressures of increasing population, dietary changes, depleting and degrading natural resources (soil and water), climate change, and shortage of skilled human resources and continued fragmentation of land leading to agrarian distress. Impacts of the past approaches, focused on technology-led development and investment have been impressive in terms of production and productivity, which has achieved much higher levels. Earlier, policies, programmes, technological changes and initiatives were designed and implemented for achieving higher production through improving productivity parameters, as it was important to achieve self- sufficiency in food, a primary concern than looking to the challenges of producing and helping the farmers in achieving improved farm income. To achieve enhanced farm income and address malnutrition effectiveplanning for diversification to horticulture has been called. With the initiative of mission approach horticulture has emerged as best option for addressing many of concerns including nutritional security. Indian horticulture a core sector of agriculture,represents a wide range of horticultural commodities, which includes fruits, vegetables, nuts, ornamental, plantation, tuber, spices, medicinal and aromatic crops and mushrooms. Collectively, these horticultural crops make a significant contribution to the Indian economy, in terms of rural employment generation and farmers income beside nutrition. Increase in demand for horticultural produce due to greater health awareness, rising income, export demands and increasing population poses the challenge for further increasing the production and productivity of horticultural crops. The issue of climate change and climate variability has thrown up greater uncertainties and risks, further imposing constraints on production systems. The challenges ahead are to have sustainability and competitiveness, to achieve the targeted production to meet the growing demands in the environment of declining land, water and threat of climate change, which needs innovations and its adoption for improving production in challenged environment. The sustainable development of horticulture is inevitable to ensure nutritional security and improved farmer's income. The paper deals on nutritional security through horticulture, challenges and options.

3.1.2 Technological advancements in vegetable seed Production: a precision system

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'Precision Agriculture' aims at increasing productivity, decreasing production costs and minimizing the environmental impact on farming. This concept involves the development and adoption of knowledge based technical management systems with the main goal of optimizing profit. The system will likely to include the ability to vary or tailor the rate of application of all inputs such as seed, water, fertilizers, pesticides, herbicides and other cultivation practices. The small farm holding in India as compared to agriculturally advanced countries limits economic benefits from currently used precision farming technologies. Nevertheless, interventions like geographical positioning system (GPS), geographical information system (GIS), artificial intelligence (AI), robotics, drones, sensor technologies, etc., are being utilized for precision vegetable farming to improve production and quality of vegetables. As compared to seeds of field crops, most of vegetable seeds are considered high value and low volume; hence these require precision system right from plan of sowing to harvesting which would include field isolation and rouging operations. To obtain good quality and maximum seed yield at relatively low cost the techniques and mechanisms such as male sterility (GMS,CMS,CGMS), Self-incompatibility,

gynoecious sex forms, sex modifications, cryopreservation of pollen and protected cultivation needs to be followed.

3.1.3 Neglected fruit species for nutrition and health Security and their precision production

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Among the major challenges the planet Earth is facing, food and nutrition insecurity is affecting large portion of population especially women and children. Hunger and malnutrition threaten more than 820 millions of people in the globe especially the inhabitants of African and Asian countries who often experience food and nutritional insecurity. Cultivation of few crops in large area and rearing of few animals in large number has resulted narrowing the food basket besides erosion of genetic diversity of important food and nutritritious crops. Hence the answer for this big challenge of nutrition and health insecurity lies in broadening and promotion varied genetic diversity of crops and animal species in our food basket. Among the agriculture crops, vegetables and fruits play a major role in mitigating the problems associated with nutrition and health. Fruits which are distributed and available abundantly in all the climatic regions supplement desired mineral, vitamins and enzymes hence, assumes prominent place in food basket. To augment the diversity of underutilized fruit species work has been initiated and so far 263 varieties belonging to 118 species of 67 genera and 35 families have been collected and maintained in the genetic diversity park at Bengaluru center of Bioversity International. Based on the preliminary evaluation of fruit characters, nutrition profiling, nutraceutical properties, besides other agronomic attributes, species/varieties belonging tro families *Annonaceae,Myrtaceae, Moraceae, Moringaceae, Leguminosae, Rutaceae, Sapindeceae* have been identified as potential for addressing the issues of nutrition and health insecurity. Precision methods for sandardization of multiplication protocols for each species and varieties for development of true to type seedlings/grafts for mainstreaming are followed. Details of the custodian farmers were documented to promote the concept of virtual gene bank for the effective conservation and sustainable utilization on a participatory mode. Besides, climate resilience and income potential for small and marginal farmers are also being studied. The findings of this program are discussed in this paper.

3.1.4 Augmenting rural economy through arid and semiarid horticulture: Scientific leads to expand scope and opportunities

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With emphatic success in achieving self-sufficiency in food grain production, India’s march for filling

the gaps in nutritional security has begun to yield dividends. This can be partially attributed to transformation of rural economy brought by the transition of agriculture from subsistence to entrepreneurship conspicuously through horticultural options. This transformation was largely driven by scientific advances in water economy in agriculture as well as genetic improvement that harnessed biodiversity in adaptation to harsh agro-ecologies of arid and semiarid region. As it is increasingly visualized, future of rural economy in these regions would depend on parallel efforts to align gains from volume with gains in content of horticultural products. It demands focus on marketable leads from basic science that can guide integrated management of inputs from farmers as well as nature to sustain the crop production and product quality. This approach should be implemented in a way to enhance economic gains from international markets as well as from the segment of domestic market that is driven by the health-conscious consumers. In this regard, the scope to expand opportunities are likely to be determined by advances in science of weather prediction, remote sensing of soils to delineate target environments, quality plant material, plant responses to combinations of abiotic stresses, metabolite accumulation and shelf life. Further, it is possible to reduce the cost of production and cost to environment, if the basic knowledge in these areas of science is integrated with emerging options in machine learning and artificial intelligence for precision in input use as well as quality assurance all along the value chain. This can further expand the scope for rural enterprises and employments and thus can augment horticulture driven rural economy of arid and semi-arid region.

3.1.5 Approaches for management and tolerance of drought and heat stresses in oil palm

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Oil Palm is known to be highest vegetable oil yielding crop and has been introduced in India to bridge the gap between demand and supply of vegetable oil in the Country and thereby reduce foreign exchange. The major abiotic challenges faced by the crop for proper growth and development are drought and heat stress. Both these factors play an important role in deciding the vulnerability of the region under cultivation. In this context, ICAR-IIOPR has undertaken studies in developing different approaches for management and tolerance of drought and heat stress in oil palm for the past two and half decades. These approaches can be partitioned into morphological, biochemical, physiological, and molecular aspects. Morphological parameters like stomatal density, pore size, etc has been extensively studied in different oil palm germplasm. Biochemical characters like SOD's, Peroxidases, catalases, epicuticular wax, chlorophyll stability index, membrane stability index, carotenoids, proline, glycine betaine, etc have been recorded in oil palm genotypes. Physiological aspects like Stomatal resistance, Transpiration, Fv/Fm ratio, Photosynthetic water use efficiency, Canopy temperature difference, etc have been documented and drought tolerant oil palm germplasm have been identified. Work on QTL's on drought and heat stresses in oil palm are under progress. The above mentioned morphological, biochemical, physiological, and molecular aspects will be reviewed here. The approaches in tolerance of drought and stress like conventional breeding, molecular breeding, transgenic approaches, and gene editing will be discussed. Stress management approaches like Agronomy and crop management, hybrid selection, chemicals & microbes and tolerant hybrids are being highlighted in this paper.

3.2 Oral Presentation

3.2.1 Evaluation of potato clones under heat stress condition in northern plains

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Potato (*Solanum tuberosum* L.) is third most important food crop and ranked first among the non-cereal crops. Its demand is increasing in due to high-industrial value and population blast. Due to global warming, Earth's temperature is increasing continuously, which has undesirable impact on potato production. While climate change may impact biotic stress either positively or negatively, abiotic stresses are likely to be greatly increased and become a major threat to potato production. In the present study the desirable heat stress parents were used in making crosses to produce ture potato seed in 2016-2017. Nursery raised and healthy seedlings were transplanted in the field in 2017-18. The F_1C_1, F_1C_2 F_1C_3. F_1C_4 and F_1C_5 generations were evaluated in at 75 days crop durationduring 2018-2019, 2019-2020 and 2020-2021crop seasons. Significant differences were recorded among clones for tuber yield and tuber attributes like plant vigour (1-5 scale), foliage senescence (10-100 scale), specific gravity and tuber dry matter content (%). In Advanced stage F_1C_4 and F_1C_5 total 18 clones along with check varieties Kufri Bahar, Kufri Kiran, Kufri lauvkar, Kufri Lima and Kufri Surya were evaluated in a replicated trial with 40 tubers in each replication at 75 DAP. At harvest 6 hybrids were selected. Hybrids namely, HT/17-223 (22 t/ha), HT/17-162 (20 t/ha), HT/17-257, HT/18-487 (17 t/ha), HT/15-240, HT/17-202 (16 t/ha) were found to be promising or yielded at par with either of the control variety under trial. The highest specific gravity and dry matter was recorded for the hybrid HT/15-107 (1.093% and 23.0%) followed by HT/18-406 (1.084% and 21.1%), HT/18-23(1.078 and 19.8%), HT/18-187(1.077 and 19.5%) and HT/18-113 (1.076% and 19.3%) higher than the controls Kufri Surya (1.073% and 18.7%), Kufri Lauvkar (1.071% and 18.3%), Kufri Bahar (1.069% and 17.9%), Kufri Kiran (1.065% and 17.2%) and Kufri Lima (1.059% and 15.8%). At harvest the incidence of hopper burn % was nil in HT/15-107, HT/17-257, Kufri Kiran, Kufri Lima and Kufri Surya.

3.2.2 Study of protray technology in multiplication of plant material and its effect on seedling growth of turmeric (*Curcuma longa* L.) varieties

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The present investigation on "Study of protray technology in multiplication of plant material and its effect on seedling growth of turmeric (*Curcuma longa* L.)varieties" was conducted at College of Horticulture, Rajendranagar, SKLTSHU, Mulugu during 2019-20. The experiment was laid out in Factorial Randomized block design (FRBD) with 3 replications and 12 treatments. The results conferred that among different sizes of planting material, S_3- Vertical split of mother rhizome recorded minimum number of days for initiation of sprouting (8.66), number of days for 50% sprouting (12.55), number of days for complete sprouting (20.10), maximum seedling vigour index (2825.33) and minimum number of days taken for final transplanting (30.10). The treatment S_2 – Two nodes cutting of primary rhizome recorded maximum percentage of sprouting (94.03%). The treatment S_4 (Full mother rhizome) was recorded maximum seedling height (43.54 cm), maximum number of leaves (2.16), and maximum chlorophyll content (29.31). Among varieties, variety V_1- Salem has taken less number of days for initiation of sprouting (8.16), for 50% of sprouting (11.50 days), for complete sprouting (18.58 days), for final transplanting (25.58 days). The maximum percentage of sprouting (98.12%), seedling height (46.10 cm), number of leaves (2.86), seedling vigour index (3166.85) and chlorophyll content (31.42) were recorded in Salem variety (V_1). Interaction between size of planting material and varieties significantly influenced growth and quality parameters. S_3V_1-Vertical split of mother rhizome of Salem variety has taken minimum number of days for initiation of sprouting (5.33), for 50% sprouting (9.00 days), for complete sprouting (16.00 days), for final transplanting (24.00 days) whereas maximum seedling vigour index (3871.21) was recorded. The treatment S_2V_1- Two node cutting of primary rhizome of Salem variety was recorded maximum percentage of sprouting (99.40%). The treatment S_4V_1-Full mother rhizome of Salem variety has recorded maximum seedling height (71.19 cm), number of leaves (3.26) and chlorophyll content (33.74).

3.2.3 Conservation and domestication of critically endangered ayurvedic herb: *Chlorophytum borivilianum* (Santapau & Fernandes), Liliaceae

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Chlorophytum borivilianum herb is commonly known as safed musli. Its fleshy roots contain the saponins and used as a health-promoting drug or tonic in the ayurvedic medicinal system. Due to its aphrodisiac properties, it called as '*Natures wonder drug*', '*Natural Viagra*', '*Divya Aushad*' and '*White gold'* as well. Safed musli plant is herbaceous in nature and propagated through asexual (fleshy roots with attached stem disc portion) and sexual(seeds) means.

Tropical and Subtropical Africa are the probable centres of origin of the *Chlorophytum* genus. In India, it is naturally distributed in the hilly areas of Gujarat, Rajasthan, Madhya Pradesh and Maharashtra. Because of its high value in ayurvedic system, generally tubers of *C. borivilianum* are mostly unscrupulously collected from their wild habitats of India. Due to its overexploitation in unscientific manner by unskilled labour and destructive nature of harvesting (tuber being economic organ the whole plant is removed), shy flowering behaviour, poor seed formation, low seed germination and high seed as well as tuber dormancy have made the status of*C. borivilianum* threatened as endangered species. Therefore, conservative strategies and some innovative ideas should be initiated to protect *C. borivilianum* from becoming endangered. Hence, sustainable conservation, cultivation and utilization of these species is highly essential and utmost important.

The commercial cultivation of safed musli has the major constraints like, non-availability of superior and uniform planting material (tubers and seeds), high cost of the quality planting material, lack of technical information, lack of in-depth study on its chemistry of species, non-availability of proper marketing channel with reliable demand-supply chain at national and global level. To address all above bottlenecks, ICAR-DMAPR, Anand have been taken some steps *i.e.*, collection and conservation of wild germplasms (54), crop improvement programme for high yield and quality, standardization of good agricultural (GAPs) and manufacturing practices (GMPs) with the objective of conservation of endangered *C. borivilianum*species and it will be worthy to bring out these species as an alternative profitable crop (Gross returns Rs. 5.5 to 6.0 Lakh/Ha/Year) for the farmers in the traditional as well as non-traditional area through commercial exploitation and domestication.

3.2.4 Remote sensing applications in potato characterization

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Potato is commonly consumed non-grain food in the world. Due to its importance in the food industry supply chain, potato has become a dominant crop in many countries. However, the continuously enhanced use of agricultural inputs could lead an environmental degradation. Moreover, the over and/ or inefficient use of water, fertilizers, pesticides and herbicides causes economic losses and negative impacts on the environment. To constantly and sustainably meet the increasing needs for potato production, reducing environmental losses with improved potato productivity, precision agricultural activities for potatoes is the solution. Precision agriculture has been gradually applied to monitor the crop growth status, generate auto-irrigation systems and disease detection systems in both developed and developing countries. Based on the interaction of electromagnetic radiation with soil and canopy reflectance, the remote sensing technique is considered as an effective tool in precision management for optimizing the decision-making process, which helps to improve profitable tuber yield, quality and minimize the negative impacts on the natural resources. Remote sensing has been utilized extensively in precision agriculture for in-season crop growth monitoring and yield prediction. Vegetation indices calculated from remote sensing images are used to correlate to yield variability through statistical and machine learning models. Multi-temporal remote sensing monitoring across the growing seasons can uniquely offer insights into yield formation processes. Remote sensing systems, integrating advances in imaging, data processing and computing technologies thus have the potential to monitor the crop growth status and help make the decisions for crop management.

3.2.5 Assessment of anti cancer activity of *Nigella sativa* L., seed extract and isolated thymoquinone tested against human myelogenous leukaemia (K652) cells

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Kalonji or Nigella *(Nigella sativa* L.,) is an annual herb in the Ranunculaceae family, the seeds of this plant have been used for thousands of years as an important nutritional flavouring agent and natural health remedy in traditional folk medicine for the treatment of numerous disorders in ancient systems of Unani, Ayurveda, Chinese, and Arabic medicine. The seed and seed extracts have anti-inflammatory and antioxidant properties, and are used by patients to suppress coughs; dissolve renal calculi etc. and the majority of the pharmacological properties of nigella seeds or extracts are attributed because of active metabolite thymoquinone. The *in vitro* anticancer activity of methanol seed extract and isolated thymoquinone were assessed against human myelogenous leukaemia (K652) cellsusing MTT assay by exposing 0.25-1.25 mg ml^{-1} and 5-100 µM ml^{-1} of methanol seed extract and isolated thymoquinone respectively for 24, 48, and 78 hours duration.The methanolic seed extract at 0.25 mg ml^{-1} recorded 65%cytotoxicity and it resulted in moderate anticancer activity at 24 hour duration treatment; the same concentration has reported 78% and 79% cell death when tested for 48 and 72 hours duration and indicated severe cytotoxicity against K562 cancer cell lines. The isolated thymoquinone treated for 24 hour duration at 5 µM ml^{-1}, 25 µM $ml^{-1}$and 50 µM ml^{-1} caused 50%, 63% and 72% cell death respectively and indicated moderate reaction against cancer cell lines. The results of the study reveal that the Nigella seed extract and isolated thymoquinone have potential anticancer activity by affecting the death of cancer-causing cell lines in a concentration and time-depended manner and demonstrated the significance of the crop in pharmacology and its potential use in the pharmaceutical industry for the treatment of cancer disease.

3.2.6 Nursery techniques for kernel germination in oil palm to enhance planting material production

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The oil palm planting material production and supply is a lengthy and cumbersome process and making sufficient oil palm planting material readily available to the farmers is one of the main key determines the success of National Mission on Edible Oils – Oil Palm (NMEO-OP) recently launched by GoI which aims to cover 10 lakh ha under oil palm by 2025-26. As per estimate, 975 lakh quality oil palm planting material is required to cover the targeted additional area of 6.5 lakh ha in the next five years. The present domestic production from five oil palm seed gardens revolving around 10-12 lakh sprouts per annum. The normal, plantable, well developed sprout production from seeds of indigenous seed gardens ranges between 40 and 60% only and a considerable quantity of seeds either remain as ungerminated or produces abnormal sprouts at the end of germination period. Further, TZ test of embryos of ungerminated seeds revealed that most embryos are viable. Hence, a considerable quantum increase in plantable sprout production can be possible by making ungerminated but viable seeds to germinate and reducing abnormal sprout production. In conventional method of oil palm germination, mechanical dormancy imposed by thick shell (endocarp) and operculum (plate like structure just above embryo) is broken by exposing seeds to heat @ 40°C for 60-80 days followed by germination at 24°C. A pilot study was conducted and observed sufficient increase in plantable sprout production by germinating the kernel instead of seed. In kernel germination, seeds from freshly harvested bunches were dried for shorter period to detach kernel testa from endocarp and kernels were extracted from seeds mechanically by removing endocarp. The hydration of oil palm kernel shall be done for 5 days with operculum intact condition which gave the highest germination of 65% and moisture increased from 18% to 22%. Further, primary nursery was raised with sprouts of different length *viz.* small (0-3 cm), medium (3-5 cm) and large (>5cm) in protrays. Only 2 and 3% mortality was recorded in primary nursery for medium and large sprouts, respectively. Similarly, all other parameters *viz.* seedling length, girth, dry weight, no. of leaves, root volume, etc. were on par between medium and large size sprouts even after 60 days of planting. Seedlings from all three categories were transplanted in polybag for secondary nursery and evaluated. In secondary nursery also, medium and large sprouts were on par for mortality (1% in both), shoot length (80 and 87 cm, respectively), no. of leaves (12.3 and 12.7, respectively), etc. Hence, kernel germination can be a potential alternate to conventional method of oil palm seed germination to improve quality sprout production and primary nursery can be raised with 3-5 cm lengthy sprouts in portrays for 60 days and after that, seedlings can be transplanted in polybag for secondary nursery till sufficient growth is observed. The study on kernel germination and nursery techniques was done on small scale and need a detailed investigation to quantify the exact advantages over conventional method of germination and nursery.

3.2.7 *In vitro* mutagenesis in banana – A way ahead for crop improvement in climate change

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The present investigation was carried out at, Department of Horticulture, VNMKV, Parbhani with an objective to induce variation in base population of Grand Naine variety of banana and to isolate dwarf and early type. The shoot tip of banana cv. Grand Naine were exposed to ^{60}Co gamma rays doses ranging from 0, 10, 20, 30, 40, 50 and 60 Gy @ 20 Gy/min. at BARC, Mumbai. The irradiated explants were sub-cultured (M_1V_0) onto shoot proliferation medium (MS medium containing 2mg/l BAP. Further sub-culturing was performed at an interval of 30 days upto M_1V_4 generation and then transferred for rooting media (1/2 strength MS medium supplemented with 2 mg/l IBA and 3g/l activated charcoal) to obtain rooted plantlets. After primary and secondary hardening finally three months old banana plants cv. Grand Naine of M_1V_4 generation were eventually planted in field. The results revealed that there was an inverse relation to plant growth, finger and yield characters of banana that they decreased with increase in doses of gamma irradiation. In all seven putative mutants were isolated from base population based on their short stature and early crop maturation. Dwarf type of mutant may be advantageous for high density planting and resisting to lodging of plants due to abrupt wind velocity and rains under climate change situation and early flowering might be useful to adopt under annual cropping system.*In vitro* mutagenesis is less expensive, bio safe and non - patented form of biotechnology approach of crop improvement in comparison to genetic transformation of plants.

3.2.8 Influence of amberlite XAD-16 adsorbent on Bitterness and sensorial quality of pummelo fruit syrup

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Pummelo (*Citrusgrandis* (L.)Osbeck is an important underutilized fruit crop grown mainly in the states of North Eastern region of the country. The fruit is an excellent source of many health promoting compounds and pharmaceutical ingredients. However, pummelo is not very much popular among consumers due to its intense bitterness. Consumers dislike to consume fresh juice and processed products of pummelo juice. The main bittering compounds present in pumelo juice are flavonoids (naringin, responsible for immediate bitteness) and limonoids (limonin, responsible for delayed bitterness) found in the fruit itself and get extracted along with the juice. The presence of bittering compounds is

the major problem of people's dislike and a limiting factor for commercialization of processed products prepared from pummelo juice. The present investigation was therefore, aimed at reducing bitterness of juice by using adsorbent Amberlite XAD-16 prior to preparation of pummelo fruit syrup and evaluation of sensorial quality of the same. Treatment with Amberlite XAD-16 resin was found to be very effective in removing the bitterness from pumelo fruit juice. A 40% reduction in naringin and 88% reduction in limonin were recorded. It was interesting to note that Amberlite XAD-16 was more prominent in reducing limonin mediated delayed bitterness as compared to naringin mediated immediate bitterness.

3.2.9 Approaches for potato seed production

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Potatoes, considers as the third most important food crop globally, is a major crop for both food security as well as income generation source in many tropical countries. Traditional seed potato production systems have been copied in many decades with minimal success. Prevalence of soil borne diseases and virus diseases build up over several generations of seed propagation coupled with prolonged seed storage at warm ambient temperatures are major constraints of potato. The high transportation cost is borne by the poor farmers who have to pay high seed prices as well. To make matters worse, the high price does not guarantee high quality, thus making it difficult for small and marginal farmers to invest such a large sum in seed purchases which accounts for nearly half of the total cost of production. Seed potato production through ARC technology is away to produce high quality potato seed, which would benefit the major potato production areas. ARC technology allows a seed producer to produce large quantities of seed potato from a relatively small piece of land. This is achieved through strict field hygiene and intensive control of pests and diseases. They have faster regeneration potential and are true to type. It is critical to maintain the mother plants in a juvenile simple rounded leaf state. Potato apical rooted cuttings (ARC) have been developed under tissue culture technique. Minituber production of ARC has been made both in substrate as well as in aeroponic systems. Mini tuber of ARC have resistant to biotic and abiotic stress. ARC revolution is bringing a great deal of excitement and promise of prosperity to remote and resource poor communities. The aim of Climate resilient agricultural programme on Potato to disseminate the ARC technology amongst the farmers in Bihar for self sufficiency and up scaling the seed potato production.

3.2.10 Alkanity in litchi plants is directed by arbuscular mycorrhizal fungi

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Arbuscular mycorrhizal (AM) resources must be used wisely in order to increase or even maintain the sustainability of agroecosystems. Litchiis commercially significant fruit crop in India, benefit from AM symbiosis, but little is known about the AM fungus associated with the litchi plant. Mostly the soils of litchi growing areas, particularly in Bihar state are alkaline in nature ranging pH from 7.5–8.5. Beside of this, Bihar is the hub of the best litchi fruits in India. Litchi, being an important woody mycorrhizal fruit tree, roots of these plants establishes a symbiotic association with arbuscular mycorrhizal fungi (AMF) to aid nutrient and water absorption for the associated plant. Arbuscular mycorrhiza improves the physical, chemical, and microbiological processes in plants. In addition, the mycorrhizosphere could increase the number of beneficial microorganisms to resist soil-borne pathogenic bacteria. Such functioning of the mycorrhizosphere produces lots of physiological effects on stress tolerance, nutrient absorption, tree growth, and fruit quality in fruit crops. In recent years, as a bio fertilizer and bio protector, AMF has attracted the attention of many horticulturists in salt-stress alleviation. AMF can improve the productivity and root-system biomass of inoculated crops, contribute to salt tolerance, and enhance plant growth. Improved salt tolerance mycorrhizal colonization may be the result of more efficient nutrient uptake reduced levels of water stress, lower disease incidence, and increased photosynthesis ability. Since litchi has high nutritional value, post-harvest value and export potential such information on the level of soil pH for the successful cultivation of litchi with some soil reclamation and mycorrhizosphere association could help to increase the crop yield of litchi.

TECHNICAL SESSION-4

INNOVATIONS IN PRECISION MANAGEMENT OF FRUIT CROP AND PLANTATION

4.1 Keynote Lecture

4.1.1 Precision production of palms with special reference to oil palm

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Right from the start of growing crops for food and nutrition, the cultivation process has undergone many spectacular changes in the recent past. Ancient agriculture could produce sufficient food since the population was less and the arable land available was more. Over a period of time the population had considerably increased and still continues to increase. To feed the increased population it was necessary to produce more and so more land was converted for cultivation. New crops were also introduced. From organic agriculture, it was changed to chemical farming by applying inorganic fertilizers to increase the production per unit area. Irrigation potential was also developed but not adequate due monsoon failure/ short of rainfall. On one side conservative agriculture, natural farming, organic farming etc., are going on, many pest and diseases, loss of soil health, depletion of ground water deficit are posing threat to agriculture/ horticulture. Therefore, precision farming with inter/ mixed and multiple and multi-storeyed cropping/farming systems were promoted to increase productivity and production. The challenges are fiercer and plenty, such as meagre and fragmented land holdings, declining productivity, diminishing natural resources, fluctuating seasonal production, climatic variations, and stagnating farm incomes. At a time like this, there is need to change our approaches towards newly emerged precision farming technologies which can increase agricultural productivity. Palms like coconut, oil palm, date palm etc., are wide spaced perennials, committed to the land for a longer period and also for assured economic returns, adoption of precision production technologies will be highly useful which has been used in oil palm in a small way. This paper explains how precision technologies can help to augment the productivity and production of palms like coconut, date palms in general and oil palm in particular.

4.1.2 Precision in grape production: a perspective

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Precision Grape production is an integrated information and production-based production system that is designed to increase long term, site-specific and whole vineyard production efficiency, productivity, and profitability while minimizing unintended impacts on the environment. Precision viticulture is a

promising management tool that can enable the development of an agricultural system to effectively manage vineyards to account for this variability. The technological tools often used in precision viticulture include global positioning systems (GPS), remote sensing (RS), geographical information systems (GIS), and variable-rate technology (VRT) and robots are being developed and used more frequently in some parts of the world in recent years. Developments and abilities of computers, software and informatic systems to read, analyze, process and transfer a huge amount of data are major milestones in precision viticulture. In addition, different decision support systems (DSSs) for making better crop management decisions at the right time also assist vine growers. In India having fragmented small vineyards, relatively cheaper technologies like UAV, proximal monitoring through various tools, and DSSs developed by the ICAR-NRCG can be used by individual grape grower or through farmer's firms to make grape cultivation technologically, economically and environmentally viable. There are mainly two aspects of precision viticulture. These are monitoring technologies, that are used for mapping spatial variability and the technologies that are utilized to provide site-specific agronomic inputs known as variable-rate technologies (VRTs) and robotics.

4.1.3 Precision production and utilization of coconut

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Coconut farming is highly heterogeneous in terms of adopted cropping systems, technology utilization and value addition. It thus required tailor made solutions for precision farming interventions which the technology-developers often ignored. However, rapid developments in ICT and IoT, especially in the wake of the 5G connectivity, make it possible now to provide customized technology recommendations to coconut growers, which is closer to the ideal scenario of precision production of coconut. A review on this subject is presented in this paper and research gaps indicated. Minimizing the use of chemical fertilizers without affecting the desired nutrient ratios is a priority area. The lead reported in the use of soil fertility maps and georeferenced data from soil health cards for creating GIS based soil fertility maps overlaid on cadastral maps to provide holding wise fertilizer recommendation may be scaled up as a network project by NRM division of ICAR in collaboration with crop research institutes. Along with this emphasize should be given for management of natural resources such as soil microbiota, conservation of soil moisture to optimize irrigation requirement, and prevention of erosion of top soil. There is large scope in coconut sector for customizing UAV applications for inventory, crop monitoring, pest and disease surveillance, forewarning and management and yield prediction. Application of wireless sensor networks for nutrient- and soil moisture management is another area calls for research in partnership mode. To integrate wide range of IoT devices and systems, an OS- and device- independent Intelligent Decision Support System for the farmers and plantation managers should be kept on place for successful implementation of smart farming in coconut sector.

4.1.4 Precision farming in mango (*Mangifera Indica* L.) cv. Alphonso especially nutrition complimenting with plantozyme

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The present investigation was carried out at AICRP on fruits, RFRS, Dr. B.S.K.K.V., Dapoli, Vengurla, during three successive experimental seasons (2017-2020) on Alphonso mango to study the effect of Plantozyme as growth promoter, stimulant on fruit set, fruit growth, yield contributing parameters and fruit quality. Along with the recommended dose of fertilizer (RDF) for mango tree, five different treatments viz. T1: RDF + Application of Plantozyme granules @ 1000 g/plant; T2: RDF + drenching of Plantozyme @ 50 ml/plant; T3: RDF + spraying of Plantozyme @ 2 ml/L, T4: RDF + Plantozyme granules application @ 1000 g/plant + Plantozyme drenching @ 50 ml/plant + spraying of Plantozyme @ 2 ml/L and T5: Control (RDF only) were replicated four times in Randomised Block Design. The drenching and spraying of Plantozyme was done for six times at new leaves emergence, initiation of flowering at 50% & 100% and fruit maturity stage. The plants were spaced 10x10 M (accommodating 100 plants per hectare). Twenty-five inflorescences/plant were randomly selected for fruit set study. Fruits were harvested at 85% maturity (B stage of physiological maturity).The results revealed that all the investigated treatments of Plantozyme application with RDF were significantly enhanced over control (RDF only). Among the treatments studied, the treatment T3 was recorded with the highest fruit set (1.26 per panicle), maximum number of fruits (214.22 per tree), weight of fruit (274.41g), fruit length (8.66 cm), fruit circumference (22.95 cm), yield of fruits (58.32 kg per tree), and yield per hectare (5.88MT). The same treatment was recorded for the best fruit quality with reducing sugar (9.97%), â-carotene (10758.24 mg/100g) and longer shelf life of 15.28 days. Also, peak amount of ascorbic acid (53.78mg/100g), TSS (19.93^{0}B) and total sugars (14.837%) were recorded. Thus, it is concluded that precision farming in Alphonso with Plantozyme was most effective in upliftment of fruit set, yield attributes, fruit qualities and overall acceptability score of Alphonso mango.

4.1.5 Precision management in cashew for improved productivity

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The cashew is an important horticultural crop introduced to India from Brazil by Portuguese travellers during l6th century. Cashew was utilised to mitigate soil erosion along the coastal areas in west coast. In India, cashew is cultivated on a wide range of soil types such as sandy to sandy loam, laterite soil, loam, and red latosols. Due its drought hardiness, cashew is widely cultivated in degraded hillocks and slopy lands, where profitable production of other crops is not possible. The potential of cashew was

first reahzed by India during early 1900s through export of kernels. Since beginning, India dominated the cashew production and trade. In the current scenario, there is a huge demand for cashew kemels both for domestic and international markets. India imports raw cashew nuts from other countries to meet the demand of processing industries. Of late, the import possibility from many of the other countries is dwindling. The aspect of self-sufficiency in raw nut production is possible through adoption of improved technological interventions by stakeholders. High density planting with a spacing of 4m x 4m instead of 7.5m x 7.5m made it possible to accommodate more number of plants per hectare and increase in yield by 2.5 folds in the initial decade of plantation. The ultra-high-density planting technique with 1111l or 1600 plants per hectare with a spacing of 2.5mx 2.5mwith 'an ability to realize a potential yield of I .5 kg/plant from the second year of planting itself, by following the relevant agro - techniques was also standardised. Nutrient management, drip irrigation, intercropping, soil and water conservation practices and canopy management through pruning and top working or rejuvenation of old senile orchards to increase the productivity are some of other technologies developed. The phenological studies were carried out in cashew for the first time at global level by using BBCH scale and seven important principal growth stages and37 secondary stages were identified in cashew according to BBCH scale. Mechanization of harvesting, applications of drone and proper crop protection at critical phenological stages will contribute to realizing higher cashew productivity in India.

4.1.6 Precision production technologies in spices for doubling farmers' income

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The demand for spices and spice-based products is increasing and sustaining their production in the era of climate change is a great challenge. The temperature is rising, rainfall is erratic, and the frequency of extreme weather is increasing. There is great scope to improve the productivity of major spices by adopting technologies that will help to bridge the gap between potential yields realized in the research stations/progressive farmers' plots.Identification of efficient climate analogue sites, creating soil resilience, practice of organic farming, growing climate resilient varieties, water harvesting and recycling, efficient irrigation systems and fertilizer use techniques, use of bio-control, growing multiple cropping with integrated farming system, following crop advisories for timely operations, protected cultivation for off-season production, mechanization for planting, intercultural operations and harvesting and institutional support would greatly help in sustainable spices production.

4.2 Oral Presentation

4.2.1 Response of different canopy shape management on yield and quality of mango cv. safed maldah under high density planting system

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A field experiment was conducted with an objective of improving yield and quality of mango cv. Safed Maldah (fifteen year old) under different canopy shape management and polyethylene mulching in high density planting (5.0 x 5.0 m) in farmers field of E. Champaranduring 2020-2021. The experimental plot was irrigated with a drip irrigation system having four emitters per plant of eight LPH capacity based on four irrigation levels (50, 75 and 100%) of pan evaporation (PE) replenishment and one ring basin irrigation method (control). The black polyethylene mulching (100 µ thicknesses) was used to cover 40% area of tree canopy. Recommended dose of fertilizer was applied at different phenological stages. The impact of different canopy shape viz. Central Leader System, Modified Leader System, Open Centre System on flowering and fruiting pattern was studied. Enhancement in flowering in tune of 75 to 90%, maximum fruit yield (95.00 kg/tree) in open centre system with polyethylene mulching treatment followed by modified leader system (80.05kg/tree), Central leader system (65.75 kg/tree) and minimum yield (60.50 kg/tree) in control (unmulched basin irrigation) was recorded. Maximum A grade fruit (35%) was also observed in open centre system with polyethylene mulching by application of irrigation at 75% PE per day per plant whereas minimum A grade fruit (17%) was recorded in the control treatments. Irrigation through drip and fertigation also increased the harvesting period of mango up to one week.

4.2.2 Mechanism of flowering control in mango

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Flowering is an important aspect of plant biology and in mango it is one of the most crucial events for commercial success of crop. Flowering behavior of many popular mango cultivars is irregular or shows alternate year flowering. Number of factors are responsible for the induction of flowering in mango which includes horticultural, environmental, biochemical and genetic. Most of the genetic factors operate through an intricate network of genes. The network of these genes has been studied well in model plants and several flowering pathways have been identified. These include photoperiod pathway, vernalization, autonomous, gibberellins (GA) and a newly identified age pathway. In the past few years our group has been involved in characterization and expression studies of genes of flowering pathways in mango. Gene homologues were identified, cloned, sequenced and their expressions were studied at

different phenological stages in various plant tissues. The florigen or flowering factor known for a long time is now identified as the *FLOWERING LOCUS T* (*FT*) gene in model plant. Homologue of the *FT* gene is also functional in mango and plays a central role in flowering regulation; it has at least three copies in the mango genome (*MiFT1*, *MiFT2* and *MiFT3*). Structurally a close relative of *FT*, flowering repressor *TERMINAL FLOWER LIKE 1* (*TFL1*), *MiTFL1* and *MiTFL1a* are also involved in regulation of flowering specially maintaining vegetative phase in mango. The *FLOWERING LOCUS D* (*FD*) which interacts with FT has also been identified by us in mango and is involved in regulation of flowering. Another important group of genes regulating flowering in mango are those regulated through circadian rhythm. These are *GIGENTIA* (*GI*), *FLAVIN BINDING KELCH REPEAT F BOX 1* (*FKF1*), *CYCLIC DOF FACTOR 1 LIKE* (*CDF1*) and *CONSTANS* (*CO*). GI-FKF1-CDF1-CO works as a module and seems to be working in mango although it is a day-neutral crop. The presence of temperature sensitive elements in the promoter region of *GI* may be the key to the temperature dependent flowering regulation in mango. Other genes involved in regulation of mango flowering are *SUPPRESSOR OF OVEREXPRESSION OF CONSTANS1* (*SOC1*) and *SHORT VEGETATIVE PHASE* (*SVP*). A group of microRNAs has been also identified in mango which is involved in regulation of flowering in model plants. The microRNA 172 (miR172) is a positive regulator and microRNA 156 (miR156) is a negative regulator of flowering in mango. The interaction of above positive (*MiCO1*, *MiCO2*, *MiFT1*, *MiFT2* and *MiFT3*, *MiFD*, *MiGI2*, *MiSOC1* and *MiCDF1*) and suppressors (*MiTFL1*, *MiTFL1a* and *MiSVP*) leads to expression of meristem identity genes *APETALA 1* (*MiAP1-1* and *MiAP1-2*) and *LEAFY* (*MiLFY*) which regulate the development of floral organs. This work gives a comprehensive understanding on regulation of flowering in mango in the light of the current knowledge of molecular biology of flowering.

4.2.3 Studies on flowering related genes of Mango (*Mangifera indica L.*)

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Better understanding of molecular and genetic aspects of flowering of Mango (*Mangiferaindica* L.) can help to resolve alternate bearing through breeding or new cultivar development. Till date three *FTs*, four *TFL1s*, two *AP1*, two *CO* and one *SOC1* genes have been reported in mango. However, it is not clear which genetic network is responsible for the induction of master regulators like *MiCO* and *MiFTs*. The present study is focused on genes which are involved in upstream and downstream of *MiCO* and *MiFT*s. The results showed that mango possessed at least two *GIGANTEA*, one *FKF1* and one *CDF1* circadian clock regulated genes and two other MADS-box genes namely one *SOC1* and *SVP* genes that work upstream to *CO* and *FT*. We also identified and characterized one *FLOWERINGLOCUSD* (*FD*) gene that functions in floral apex, Two *AP1* (*MiAP1-1* and *MiAP1-2*) and one *LFY* which are known to be flower meristem identity genes working downstream of FT-FD complex and two miRNA (miR156 and miR172) that are involved in mango flowering. The expression studies showed that *MiGI*, *MiFKF1* and *MiCDF1* genes followed the circadian rhythm. The expression pattern of *MiFD* gene in the apex tissue of flowering plants may be to interact with mango FT to induce flowering and in the apex tissue of non-flowering plants to interact with mango TFL1 to repress flowering. The FD-TFL complex represses flowering while the FD-FT complex stimulates the expression of downstream genes *AP1*, *AP2* and *LFY*. Our study reflects on the characteristics of *MiGI*, *MiFKF1* and *CDF1* genes

that function upstream of *CO*, the characteristics of *SOC* and *SVP* that seem to function upstream of CO, the characteristics of *FD* of mango functioning in the apex and the 3 genes (*MiAP1-1*, *MiAP1-2* and *MiLFY*) that function downstream of FT-FD complex.

4.2.4 Effect of growth regulators and chemicals on PAR, LAI and yield of mango (*Mangifera indica* L.) varieties under ultra high density planting system in Telangana state

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The experiment was designed in factorial RBD concept in Ultra High Density Planting System of Telangana orchard during 2021-22. Four mango varieties (*Viz*., Baneshan, Dasheri, Himayat and Kesar) were treated with growth regulators and chemicals (*Viz*., *i)* KNO_3 @ 10g/l, *ii)* KNO_3 @ 10g/l + PBZ @ 3ml/m; *iii)* KNO_3 @ 10g/l + CPPU 1ml/l; *iv)* KNO_3 @ 10g/l + K_2SO_4 @ 10g/l; *v)* KNO_3 @ 10g/l + CPPU 1ml/l + K_2SO_4 @ 10g/l; *vi)* KNO_3 @ 10g/l + PBZ @ 3ml/m + CPPU 1ml/l; *vii)* KNO_3 @ 10g/l + PBZ @ 3ml/m + K_2SO_4 @ 10g/l; *viii)* KNO_3 @ 10g/l + PBZ @ 3ml/m + CPPU @ 1ml/l + K_2SO_4 @ 10g/l) to analyze their effect on yield, LAI (Leaf Area Index), interception of PAR (Photosynthetically Active Radiation) and earliness of flowering. The results revealed that yield was significantly and positively correlated with interception of PAR and LAI in ultra-high density planting system. Two Sprayings of KNO_3 @ 10g/l + PBZ @ 3ml/m + CPPU @ 1ml/l + K_2SO_4 @ 10g/l (*viz*., one at the time of flower bud differentiation and another at fifteen days after first spraying) on four mango varieties was successfully increased the yield (39.25%) by increasing the PAR (7.61%) and LAI (7.76%) of the plants. And the treated plants recorded early flowering *viz*., Baneshan, Dasheri and Kesar varieties by 6 days respectively and Himayat by 14.33 days when compared to plants treated with KNO_3 @ 10g/l.

4.2.5 Quality planting material of citrus saplings production an initiatives by Jain Plant Factory

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After mango and banana, citrus is the third most important fruit crop in India. Among *Citrus spp.* availability of disease free, healthy quality planting material of sweet oranges and mandarins is a great

challenge whereas there is a great demand for these planting materials. Jain Irrigation Systems Ltd. (JISL), has been a pioneer in commercial tissue culture planting material production and considers it as “Plant Factory” and now has named it as “Jain Plant Factory”. JISL has been working on production of quality planting material of sweet orange from 2010 and now developed an integrated hi-tech production system and facility for disease free high quality planting material of sweet orange and mandarin by adopting advanced techniques of nursery management to ensure quality and quantity of plants. Jain Plant Factory adopted the use of root trainer containerized nursery system under climate controlled greenhouses using soilless potting mixture, on table system with automated fertigation for commercial nursery production. Recent initiatives in disease free quality planting material production and micro-budding technology have been standardized for large-scale and fast multiplication (Higher percentage success rate in whole year). JISL is the only company which produces plants from virus indexed mother plants and provides tested virus free plants. JISL also has the largest area of rootstock plantations for the production of improved rootstocks which are used for the nursery production. This paper deals with the details description of quality planting material production of sweet orange and mandarin.

4.2.6 Molecular mechanisms of flowering regulation in *Punica granatum* L.

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Flowering is an important developmental process of angiospermic plants that marks the transition from the vegetative phase to the reproductive phase. In plants Phosphatidylethanolamine-binding proteins (PEBP) proteins play an important role in regulating flowering time and plant architecture. In angiospermic plants, the *FLOWERING LOCUS T* (*FT*) gene promotes flowering whereas *TERMINAL FLOWER1* (*TFL1*) like genes are responsible for vegetative development. In this study we check the expression of *PgFT1* and *PgCENa* genes in the Indian cv. Bhagwa and Turkish cv. Hicaznar varieties of pomegranate. In Bhagwa, extensive vegetative growth immediately after pruning is associated with a rapid reduction in *PgFT1* expression while the onset of flowering coincides with its expression. *PgFT1* is expressed in flower-bearing shoots but not the branches that do not bear flowers. High *PgCENa* levels and low *PgFT1* levels suppress flowering and low *PgCENa* levels and high *PgFT1* levels induce flowering. In the Indian atmosphere no significant correlation in expression of *PgFT1* and *PgCENa* was noted in Mediterranean Hicaznar varieties. Flowering and non-flowering shoots show differential *PgFT1* and *PgCENa* expression in the Indian and Mediterranean Hicaznar varieties. In contrast to *PgFT1*, the expression of *PgCENa*, the functional *TFL1* homolog in pomegranate, showed an inverse correlation with that of *PgFT1*. This suggested that relative reduction in *PgFT1::PgCENa* ratios in non-flowering shoots was associated with a lack of flowering in pomegranate, while an increase in these ratios was associated with flowering in both the Indian and Hicaznar varieties. The study provides insights into the molecular mechanisms by which pruning affects flowering pathways in tropical perennial fruit plants.

4.2.7 Role of circadian clock genes in mango flowering

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Mango (*Mangifera indica* L.), an important fruit crop of the tropical and subtropical regions shows alternate bearing in most varieties causing a financial loss to the farmer. Genetic reasons for this undesirable trait have not been studied so far. In our attempts to investigate the genetic reasons for alternate bearing we have initiated studies on genes associated with the induction, repression and regulation of flowering in mango. In present study, we have explored the association of GI-FKF1-CDF1-CO module with the regulation of flowering in mango. The role of this module in regulating flowering has been well documented in photoperiod sensitive plants. We have characterized these genes and their expressions during flowering in Ratna variety as also their diurnal fluctuations and tissue specific expressions. The data taken together suggest that GI-FKF1-CDF1-CO module may also be employed by mango in regulating its flowering. Further we suggest that the temperature dependent flowering in mango is probably associated with the presence of temperature sensitive elements present in the promoter region of one of the *GIGANTEA* genes that have been shown to be closely associated with floral induction.

4.2.8 Economics of protected cultivation of tomato for improved livelihood in Jharkhand

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Vegetable production under protective structures is gaining importance in south East Asia. Tomato is the most universally grown greenhouse vegetable crop found in varied agro-climatic conditions. Indeterminate varieties that set fruit for almost a year are economically profitable under protected cultivation. Swarna Anmol,multiple disease resistant indeterminatehybrid released by the Centre (ICAR RCER FSRCHPR, Ranchi) was used for the evaluation. Naturally ventilated polyhouse with saw tooth structure was selected for the study due to its low cost, low maintenance, ease in operations and more durability.Plant growth was profuse, healthy with average height of 4.5-5 meters. Fruiting was in clusters with average 4-6 fruits per cluster. The entire cropping period was for 10 months with 7.5 months under fruiting. First harvest started 70-80 days after transplanting. Average fruit yield was 108 t/acre. The initial investment for construction of polyhouse can be obtained by the farmers by availing subsidy under State Government or Schemes of NHM or NHB. A net return of Rs 7,25,000/- was obtained in one year after deducting the cost of cultivation. B:Cratio of 1:1.81 was found encouraging for improvement of livelihood of farmers. High market price of offseason harvest and protection from sudden changes in the weather are undoubted benefits of protected cultivation to the farming community.

4.2.9 Combining ability analysis for yield and yield attributing traits in papaya (*Carica papaya* L.)

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Papaya is a popular crop grown around the world known for its high yield potential and nutritionally rich fruits. The varieties that are grown in India for commercial cultivation is limited in number. This limitation has increased crop vulnerability to attack of insect pest and diseases, ultimately leading to crop failure. So, there is a need for development of more number of hybrids with diverse traits. Prior to the beginning of any improvement program, the parental lines should be evaluated by their combining ability. The knowledge of combining ability helps in identifying best parent combiners which may be hybridized to exploit heterosis, and superior hybrid combinations. Combining ability analysis is one of the efficient tools which helps in selecting parents and crosses for the improvement of particular characters. In the present investigation the papaya inbreds and hybrids were evaluated for thirteen traits related to vigour, earliness and yield. In randomized block design with three replicates, 6 inbreds, namely, Pusa Nanha (PN), Pune Selection 3 (PS 3), P-7-2, P-7-9, P-9-5 and P-9-12 and 30 hybrids of papaya were produced in 6 x 6 full diallel mating design (excluding the parental combinations). Parent PN, exhibited maximum negative GCA for plant height, petiole length and stem diameter. PS3 was identified as the best general combiners for yield related traits like fruit length, fruit diameter and fruiting zone. Best general combiner for fruit weight and fruit yield was P-7-9 and for number of fruits per plant and earliness was P-9-5. The hybrid, PS3 x PN showed SCA effect in desired direction for plant height, internodal length, number of nodes to first flower and days to fruit maturity.The hybrid combinations, P-9-12 x PS3, P-7-9 x PN, P-9-5 x PN, P-9-5 xP-7-9 and P-9-12 x P-7-9were superior with positive estimates of SCA effects for the number of fruits, fruit weight, pulp and fruit yield, that are the most important traits for the crop.

4.2.10 Tissue Culture as a plant production system for horticultural crops in Eastern India

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In Eastern India, although the tissue culture industry started almost a decade late in comparison to the rest of the country, its expansions in the recent years has been exponential and the facilities being created are at par with the best in the country. The tissue culture laboratory in Bihar Agricultural University, Sabour running under public-private partnership is not only one of the largest laboratories in the Eastern India, but is also one of the leading tissue culture laboratories in the country. Lack of availability of quality, disease-free planting material of major horticultural crops at reasonable price is one of the major constraints faced by the growers of the Eastern India which affects the overall production and productivity of these crops. Keeping these issues in view, currently the laboratory is engaged in large-scale commercial production of disease-free planting material of Banana cultivar Grand

Naine (G9) with an annual production and sale of 10 lakh plants. An efficient regeneration protocol through somatic embryogenesis and organogenesis has been also developed for different cultivars of pineapple and many ornamental crops with higher multiplication rate in our studies. Furthermore, the laboratory is also involved in the standardisation of efficient tissue culture protocols for different cultivars of banana, strawberry, papaya, litchi, mango, dragon fruit and other horticultural crops which includes threatened and endangered cultivars of banana viz. Malbhog and Chinya. These protocols will prove to be very effective for area expansion of Horticultural crops in Eastern India. This paper is aimed at critically analysing our ongoing tissue culture research activities and the potential role and scope of tissue culture industry for production of quality planting material of Horticultural Crops and in preserving threatened and endangered genotypes.

4.2.11 High density planting enhances the productivity of Cocoa (*Theobroma cacao* L.) in humid tropics of India

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Cocoa (*Theobroma cacao* L.) is an important beverage crop grown for its seeds, known as beans used mainly in chocolate industry. In India, it is grown as a mixed crop with coconut, arecanut and oil palm with productivity of 669 kg ha^{-1}. High density planting is gaining popularity in many of the perennial crops with wider spacing for increasing the production per unit area. Since cocoa is amenable for pruning, there is scope for high density planting in cocoa. To study the feasibility of high density planting on the productivity of cocoa, an experiment was laid out in completely randomized design at ICAR-CPCRI, Regional Station, Vittal. Grafts of cocoa variety Netra Centura wereplanted in five planting distances of 1.35 x 1.35 x 2.7 m, 1.35 x 2.7 m, 1.35 x 5.4 m, 2.7 x 2.7 m and 2.7 x 5.4 m with plantingdensity ranging from 650 to 3712 plants ha^{-1} in 2016. During the initial years (2019-22), pod yield per plant (2088-2695 kg) and dry bean yieldper plant (177-241 kg) were similar among different spacing. However, the cumulative dry bean yield per hectare during 2019-22 wassignificantly higher in closely planted grafts (966– 2627 kg ha^{-1}) than grafts under recommended spacing of 2.7 x 5.4 m (469 kg ha^{-1}) having low population density. Higher dry cocoa bean yield per hectare in closely planted grafts was due to higher plant population.The plant girth was positively correlated with dry bean yield ($r = 0.684^{*}$), and it was higher in closely planted cocoa grafts. The single bean weight (0.94 – 1.13 g) and nib recovery (84.6– 86.2 %) were similar among different spacing treatments, but they were higher in closely planted cocoa grafts than plants under normal spacing. The data indicates that, high density planting of cocoa can give bolder beans and significantly higher productivity in the initial years.

TECHNICAL SESSION-5

INNOVATIONS IN PRECISION MANAGEMENT FOR VEGETABLES CROPS

5.1 Keynote Lecture

5.1.1 Precision Management System in Urban and Peri-Urban Horticulture for Food, Nutrition and Environmental Services

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To meet their needs for food, nutrition and eco-environment, urban and peri-urban urban and Peri-urban Horticulture (UPH) is emerging as one of the options, and many international organisations are working with national partners, which call for accelerated efforts. The system has become dynamics to the Precision Management System with the concept of observe, measure and respond to get high efficiency of the inputs, FAO has provided focus on Urban and Peri-Urban Agriculture UPA for improving livelihood of urban poor, by supporting projects in member country and creating awareness through workshops and conferences. Consultations have brought focus on greening cities, guided by UPH, and its integration in developmental strategies and programs, with multi-stakeholder participation. In India, many national consultation, conferences and workshops have been organised which has brought focus on urban and peri-urban horticulture. UPH has defined the activities of greening the cities, utilising the waste, meeting the needs of food and nutrition, and servicing the environment by effective and sustainable use of natural resources through technological inputs, investment and policy. For supplementing the needs of food and nutrition peri-urban horticulture has emerged as an enterprise for production of vegetables, fruits, ornamentals and spices especially under protected environment in the country. There is a growing interest for rooftop gardening, vertical gardening, hydroponic and aeroponic system of cultivation. In this system city wastes are recycled for use which is providing employment besides meeting the needs. Well planned UPH could be a strategy to mitigate and adapt to the climate change. A key challenge, therefore, is to develop policy, strategies and technical support mechanisms for the sustainable management of urban and peri-urban horticulture (UPH), addressing production issues within a broader framework of environmental planning and management. The paper deals with dynamics of UPH in India with focus on greening the cities, supplementing the needs of food and nutrition and servicing the environment to address the challenges of climate change.

5.1.2 Precision production of tropical tuber crops

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Tuber crops are considered as plants among the oldest on earth, they are also the crops of the future, since they produce adequate carbohydrates which can substitute expensive cereals. Consumed mostly by the poorest, they contribute mostly to food security. From the status of cultivation in small and marginal holdings, these crops are gaining the status of large scale cultivation owing to the recognition of their industrial potential. They are also cash crops and are used as animal feed or raw material for industrial processing. Root and tuber crops, in addition to being an important cultivated staple food in underdeveloped and developing countries, are also a key raw material for several industries, particularly the processed food and energy industries.

Precision agriculture (PA), or precision farming as the name implies, refers to "the application of precise and correct amounts of inputs like water, fertilisers, pesticides etc. at the correct time to the crop for increasing its productivity and maximising its yields." The core concept of precision agriculture research will be the ability to define a Decision Support System (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources.

Tropical tuber crops include cassava(*Manihot esculenta* Crantz), sweet potato, (*Ipomoea batatas* (L.) Lam.), yams and aroids. Traditionally, all these crops were cultivated depending upon the rainfall availability. With improved varieties, agricultural technologies and tools, area and production have increased, however, the potential productivity of these crops has not attained, under rainfed conditions. Because of the increasing demand and identifying the industrial potential, the cultivation of these crops has been expanding to non-conventional areas. This necessitated irrigation in few crops. There is great scope for adopting precision technologies for improving the production of these crops considering their immense yield potential.

Scope of precision farming in tuber crops

Tropical tuber crops were once considered as poor man's crop or low value crops, as they produce satisfactory yields even under low or average management conditions. But the crops respond well to the application of inputs. The high industrial potential, in varied dimensions, as starch, biofuel and energy, animal feed, medical preparations etc., make a wider avenue for precision production of tuber crops. Resilience to climate change of most of the crops makes them the future crops, in place of other high starch crops. Precision farming can ensure efficient use of water resources, reduction of chemical use, enhanced productivity in view of their industrial potential, reduction in the yield gap, modern farm practices to improve quality and quantity, and reduction in cost of production. Government programmes like "Prime Minister Krishi Sinchayee Yojana" are encouraging the farmers to adopt precision irrigation.

R&D efforts for precision cultivation of tropical tuber crops

Though there is great scope for precision farming in tuber crops, R and D initiatives for developing "Precision technologies" in tuber crops cultivation are attempted only in the recent past. In India, these crops are attaining the status of commercial crops, in many states. Cassava has attained commercial status in the states of Tamil Nadu and Andhra Pradesh. Similarly, elephant foot yam has attained commercial status, especially in the states of Andhra Pradesh, Odisha and Bihar. Farmers also started using some of the precision farming tools viz., micro irrigation, fertigation etc in the commercial belts.

Many precision tools like drip irrigation and fertigation schedules, novel water saving technologies, site specific nutrient management, e-crop and mobile advisory were standardized in most of the tropical tuber crops by ICAR-CTCRI.

Drip irrigation

Drip irrigation is established to be a precise input technology in most of the crops, with a water use efficiency of more than 90%, compared to 30-40% under surface irrigation. The change of cassava from the status of a food crop to an industrial crop made farmers to resort to drip irrigation in cassava, in the states of Tamil Nadu and Andhra Pradesh. In Tamil Nadu, where the area under cassava is varying between 90,000 to 1,20,000 ha every year, only 20% area is rainfed. The rest of the area in plains is fully irrigated, that too more than 60,000 ha is under drip irrigation. Wherever irrigation water is available in plenty, farmers go for furrow irrigation. Though, the tuber yield reported under drip irrigation is only 20% higher than that under furrow irrigation, farmers themselves are convinced about the quantum of water saving through drip irrigation, which is almost four times compared to furrow irrigation. Studies carried out at ICAR-CTCRI revealed that cassava is to be irrigated at the rate of 100% of cumulative pan evaporation (CPE) for getting the highest tuber yield, which was 25% higher than that under furrow irrigation. Water productivity was worked out to be 8.2 kgm^{-3}as against 2.6 kgm^{-3} under furrow irrigation.

In sweet potato, drip irrigation resulted in 68 % increase in tuber yield compared to furrow irrigation. Drip irrigation also recorded a water productivity of 9.5 kgm^{-3}as against 5.6 kgm^{-3} under furrow irrigation. Drip irrigation was attempted in elephant foot yam also. There was 13% increase in corm yield and 38% increase in water use efficiency under drip irrigation compared to furrow irrigation. Drip irrigation recorded a water productivity of 4.57 kgm^{-3}as against 3.87 kgm^{-3} under furrow irrigation.

Studies carried out at Regional station, ICAR-CTCRI, Bhubaneswar indicated that drip irrigation at 80% CPE is optimum for elephant foot yam(*Amorphophallus paeoniifolius* (Dennst.) Nicolson) which recorded 27% increase in corm yield over flood irrigation. Drip irrigation also saved 431 mm of water per ha by which an additional area of 1.98 ha can be brought under cultivation. In greater yam (*Dioscorea alata* L.), drip irrigation at 80% CPE resulted in optimum tuber yield and recorded 27% increase in tuber yield over flood irrigation.

Taro (*Colocasia esculenta* L. Schott) being a moisture sensitive crop, responds well to drip irrigation. Drip irrigation at the rate of 100% of cumulative pan evaporation from planting upto six months was found ideal for early sprouting, growth, yield attributes and cormel yield, based on the studies carried out at ICAR-CTCRI. Drip irrigation recorded 45% increase in cormel yield and 2.1 times the water productivity than the furrow irrigation.

Drip fertigation

Fertigation is established to be a nutrient efficient package in most of the crops wherein the nutrients are applied in smaller quantities over a longer spell of crop requirement in the active root zone of the crop. When fertilizer is applied through drip irrigation, the yield could be increased and about 30 per cent of the fertilizer could be saved.Wherever, drip irrigation is being practiced, application of fertilizers through irrigation water, ie., fertigation, usually go side by side. So is the case with tuber crops also. Fertigation studies in cassava revealed that 50% of the nutrient dose could be supplied during the initial stages of establishment of the crop, upto 1.5 to 2 months, 30% during the active vegetative and tuber bulking phase, between 2-4 months and the rest 20% during later bulking phase of 4-5 months after planting is the most ideal. There was a saving of 25% of nitrogenous fertilizer under fertigation compared to standard fertilizer recommendation, as per studies conducted by ICAR-CTCRI.

In cassava, fertigation is a common practice in commercial belts in Tamil Nadu. Tamil Nadu Agricultural University recommends a fertilizer dose of 90:90:240 kg NPK/ ha for cassava, applied once in three days almost throughout its growth period of 8 months. Studies carried out through AICRP centre, at TCRS, Yethapur, Tamil Nadu revealed that upto 25% of fertilizer saving, both nitrogen and potassium, is possible through fertigation.

Studies were carried out on fertigation in elephant foot yam and yams by ICAR-CTCRI, Regional station, Bhubaneswar. In elephant foot yam, the highest corm yield was obtained with drip fertigation, when the recommended dose of NPK was applied at 3 days interval in 50 splits, or 40 split doses at 4 days interval. The first dose of fertilizer application should start 10 days after planting and continued upto150 days after planting for the production of higher corm yield. The practice has resulted in 33% increase in fertilizer use efficiency compared to soil application of fertilizers. In greater yam, fertigation at the rate of 140-90-140 kg N, P_2O_5 ,K_2O in 60 splits at three days interval resulted in maximum tuber yield, net income and B:C ratio at Bhubhaneswar.

Fertigation studies in taro at ICAR-CTCRI, Thiruvananthapuram indicated that application of 60- 50-75kg N, P_2O_5 and K_2O per ha @ 50% before 90 DAP, 25% during 90-120 DAP and rest 25% during 120-150 DAP is optimum and economic, thereby resulting in a saving of 25% N and K nutrients compared to package of practices recommendation. This has resulted in 83% increase in cormel yield over soil application of fertilizers.Preliminary studies on fertigation in Amorphophallus recorded 25% saving in nitrogen and 33% saving in potassium nutrients, compared to recommended POP. There was 57% increase in cormel yield compared to soil application of nutrients.

In greater yam+maize intercropping system, fertigation studies at Bhubhaneswar recorded a yield increase of 12% in maize and 18.4% in greater yam. Opportunities also exist for further increase in 30% yield by applying 17% additional N and K under drip fertigation.

Novel water saving techniques

Water is the most crucial input in agriculture and declared to become the most scarce input in near future. Hence in addition to the conventional soil moisture conservation techniques, the modern techniques of ground cover mat, super absorbent gel, partial root zone drying technique, biomulching etc are gaining importance along with drip irrigation. With these, there is still possibility of water saving in crops and such studies at ICAR-CTCRI are promising. The water requirement of cassava through drip irrigation could be reduced to 50% by covering the interspaces with porous ground cover mats. There was an increase of 48% in cassava tuber yield, compared to 100% drip irrigation, in addition to 50% saving in irrigation water.

In Amorphophallus, drip irrigation at 50% along with porous ground cover mat and soil application of cassava based super absorbent polymer (SAP) could record corm yield on par with drip irrigation at 100%. In addition to 50% saving in irrigation water, the techniques recorded 12 % and 8.5% increase in corm yield respectively. Consequently the water productivity was also higher while using ground cover mats (4.4 kgm^{-3}), and soil application of SAP (4.26 kgm^{-3}) as against 100% drip irrigation (3.26 kgm^{-3}).

In upland taro, drip irrigation at 50% CPE along with porous ground mat mulching resulted in cormel yield, 32.2% higher than irrigation at 100% CPE. Biomulching was also found effective and recorded 9% increase in yield compared to irrigation at 100%. Porous ground cover mulching also recorded 60% increase in water productivity, in addition to saving in 50% irrigation water.

Site specific nutrient management

The Quantitative Evaluation of Fertility of Tropical Soils (QUEFTS) model was calibrated and validated for site specific nutrient management (SSNM) of cassava, sweet potato, elephant foot yam, yams, taro and Chinese potato in major growing areas of India. Since 2003, more than 500 on-farm calibration / validation trials were conducted in major agro ecological regions where these crops are widely grown which comes under 12 different states during the past 20 years. Results of the studies showed significant yield advantages of SSNM over farmers' practice / present recommendation in all crops studied (cassava: 21.8%, sweet potato: 19%, elephant foot yam: 26%, greater yam: 18.9%; white yam: 21.6%, taro: 23% and Chinese potato: 14.9%).

Based on the zone-specific recommendations developed, secondary- and micronutrient-inclusive customized fertilizers were developed and validated in all major growing regions. Multi micronutrient formulations for foliar nutrition were developed and the technologies were licensed through Agrinnovate.

For real time N management in cassava, leaf colour chart (LCC) and chlorophyll meter (SPAD-502) were calibrated and validated. The LCC based N- recommendation could increase the tuber yield by 19.6% compared to blanket N recommendation which is equal to an yield increase of 4.8 t/ha. The SPAD-502 meter based N recommendation could increase the tuber yield by 16.1% which is equal to a yield increase of about 4 t/ha.

Electronic crop (e crop)

ICAR-CTCRI has developed an IoT device to simulate crop growth real-time, in response to weather and soil data collected using sensors from the field real-time automatically. The system daily calculates plot by plot yield gap and quantifies, N, P, K and water requirement to reduce the yield gap. Advisories are sent to individual farmer's mobile as SMS. Yield increase of at least by 100% and reduction in input application by 50% are observed with this device in tuber crops as well as in other seasonal crops.

Though there is great scope for precision technologies in tuber crops cultivation, the rate of implementation in tuber crops is limited, except in cassava. High initial investment and uncertainty in market price often prevent farmers from large scale adoption. Small farm size, periodical maintenance due to the seasonal nature of crops, lack of local technical expertise, knowledge and technological gaps can be some of the factors, which can be attributed for the low adoption. Climate resilience of tuber crops and the potential as biofuel can bring more area under tuber crops and with adequate financial support and technical knowhow, more area under tuber crops can be brought under precision farming in near future.

5.1.3 Precision system for vegetable grafting and nursery management

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Precision farming has greatly reduced the input cost with the added benefits of land and crop productivity and sustainability.The precise nursery practices starts with the seed treatment, nursery management, advanced propagation techniques and tools and disease and pest free practices. The Govt of Tamil Nadu along with Tamil Nadu Agricultural University has standardized the precise plug tray nursery techniques for various crops like Tomato, Brinjal, and Chilli etc. Over 90% of the people have adopted this precision farming nursery technology as they are low volume high value crops.Transplanting tomato after third week has found to reduce the whitefly infestation thus showing that the age of seedlings is correlated with resistance to Tomato Yellow leaf curl virus (TYLCV). Nematode is a major problem in the vegetable crops and to alleviate it grafting with nematode tolerant or resistant rootstocks has been a major breakthrough in TNAU and has been popularised among Tamil Nadu farmers. To improve the efficacy of the grafting certain AI approaches like the use of NDVI (Normalised difference vegetative index) is also being employed. Performance prediction of various grafted plants like Melon, Tomato, Eggplant, and Pepper through the NDVI approach has been successful and it has been found that Brinjal graft was the most efficient in giving good resistance to the nematodes. Experiments were carried out at the Department of Vegetable Science, Horticultural College and Research Institute, Coimbatore to study rootstock-driven resistance to pests and diseases in brinjal, tomato, and bittergourd. Grafting brinjal genotypes with wild Solanum species was done to mitigate root-knot nematode (*Meloidogyne spp.*) and dry root rot (*Macrophomina phaseolina*) incidence. Presently the Department is producing grafted brinjal plants and supplying to the farmers. In another experiment, a total of ten cucurbitaceous rootstocks and two bitter gourd scions were screened against Fusarium wilt pathogen under in vitro. Results on screening against Fusarium wilt revealed that *Citrullus colocynthis*, *Cucumis metuliferus* and *Cucurbita moschata* exhibited no symptom and manifested as resistant to Fusarium wilt and the least percent incidence of 21.62, 37.44 and 48.90 was observed in Luffa cylindrica followed by *Momordica charantia* var. muricata rootstock (23.58, 42.18 and 50.34) at 30, 45 and 60 days after inoculation. From this study it was found that the cucurbitaceous species viz., kumatikai (*C. colocynthis*), African horned cucumber (*C. metuliferus*) and pumpkin (*C. moschata*) with high ormoderate levels of biochemical constituents suffered less for Fusarium wilt pathogen and these rootstocks served as the best rootstocks for grafting with bitter gourd scions followed by mithipakal(*M. charantia* var. muricata) and sponge gourd (*L. cylindrica*).Precision farming in the nursery and grafted plants can offer scope for improving the productivity of vegetable crops through production of disease and pest free quality seedlings.

5.1.4 Precision production of seed spices

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The land of spices, India is the largest producer of seed spices, alone contributes 77 percent of world area and 74 percent of world's seed spice production (FAOSTAT, 2020), besides largest consumer and exporter. In India, seed spices occupy about 2.0% of gross cropped area, which has increased from 7.98 lakh ha to 21.50 lakh ha (269%) and production from 4.79 lakh tonnes to 20.60 lakh tonnes (430%) from 2001 to 2020. Overall productivity of seed spices enhanced from 600 to 958 kg/ha (62.63%), required to be enhanced further. More than 4.8 Lakh tones (23.3% of production) of seed spices exported from India valued more than Rs. 5666 Cr. during 2020-21. The country meets ~50% of the world demand of seed spices. Out of the 22 seed spices which are commercially cultivated in the country, 10 contributed around 90 percent of export earnings. Among seed spices, maximum area is under cumin followed by coriander, fennel, fenugreek, ajwain, celery, nigella, dill, anise, caraway etc. Arid and sem-iarid parts of the country (Rajasthan and Gujarat) are known as Seed Spices Bowl and contribute ~80% of total seed spices production.

Precision farming (smart farming or smart agriculture) where the resources utilization is optimized for sustainable production helps the growers in decision making process for greater success levels. It also involves the practice of using data for sustainability of production system. Satellite imagery, drones, various type of sensors, weather recording and forecasting stations are used for farming community monitoring and analysing soil conditions and for managing other resources like water, fertilizers, pests and diseases and their management besides monitoring and measuring of the abiotic stresses caused weather vagaries and/or climate change. The grower has to see and monitor plants in real time to know what actually his farm plants need. The grower has to formulate his goals/targets and select which parameter measurement will be going to support him in achieving the targets. He should be aware about his problems; by addressing them properly he can enhance the yield levels of his crop and farm.

Scientific community is regularly engaged in strong R&D activities to boost the yield and quality of seed spices from last so many years globally and proved significance as mentioned above, but still lot is to be done. The available technologies so far not enough to aggrandize the potential output of even conserved gene pool and/or developed varieties. Besides, endeavour on resource utilization for yield optimization and efficient management of biotic and abiotic stresses needs to be strengthen to have the quality production. Precision farming interventions like placement of seed at right site, at right time with right method or technology, application of inputs precisely to have potential yield, timely detection of water & nutrient requirement and accurately sensing of disease infection & insect infestation with suitable technologies and protection of these crops from various stresses with the precise application of chemicals/herbicides/pesticides/insecticides/fungicides/botanicals (like sensor based detection and application technology) at proper time can play a pivotal role in seed spices production system.

The technologies recently developed at ICAR-NRC on Seed Spices, at different centres of AICRP on Spices, in different organization (SAUs/NGOs/ private partners) etc. nationally or internationally viz., laser guided field levelling, seed priming, seed pelleting, line sowing with ferti-seed drills, pneumatic planting, nursery raising & seedling planting, micro irrigation and fertigation, raised bed plantation, mulching, green house & shade net house cultivation technology, barrier walls, vertical farming, proper harvesting at right maturity stage, efficient farm level handling, could lead to better quality produce with more than 100 per cent appreciation in existing yield levels of these crops. Besides this, scientific handling of produce after harvest, processing, product manufacturing, packaging, efficient transportation & storage, strong value chain including well organised trade & export could save the harvested produce (which otherwise we lose in the range of 15% to 25% of the total production), that ultimately enhanced the availability of quality seed spices to the end users.

Hence, it is very imperative to mention here, that precision production or smart farming taking into consideration all the production factors, could increase the yield & production of high quality seed spices, improves socio economic condition & living standard (economic security) of all the stakeholders particularly growers and boost overall economy of the country vis-à-vis enhance availability of the quality spices to the consumers worldwide, which consequently support their health security.

5.1.5 Advances in precision production system for onion and garlic to enhance profitability

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Onion and garlic are the important bulb crops grown worldwide and are used in various culinary preparations. In India, onion and garlic crops occupies 16.24 and 3.92 lakh ha and produces 266.4 lakh tons of onion and 31.9 lakh tons garlic, respectively (FAOSTAT, 2023). These are high value crops requires more manpower from planting, weeding and other intercultural operations to harvesting. Total labour charges accounts for about 60% of the total cost of cultivation of these crops. Improved cultivars and package of practices have been developed to increase the yield and quality of these crops.

With adoption of improved cultivars and production management practices, the productivity of onion and garlic cultivars have been increased considerably compared to the pre-green revolution period. There is tremendous scope to increase the productivity of onion and garlic and input use efficiency and to reduce labour time through precision agriculture. Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high technology sensor and analysis tools. Precision agriculture is a new concept adopted throughout the world to increase production, reduce labour time, and ensure the effective management of fertilizers and irrigation processes.

Precision farming: Precision farming approach is the one which combines a number of new technologies such as satellite imagery or field mapping to improve crop quality and profitability. Among the technologies used in such a system are GPS, drones, and satellite images. Based on this data, farmers receive information on all key issues: crop status, weather forecasts, environmental changes, etc. Also, **the important difference between precision farming and traditional agriculture is t**he ability to manage fields not as a single block but by dividing them into separate areas. Such zoning allows diversifying management decisions for individual field parts: adjusting the fertilizer amount, optimizing technique movement and using fuel more economically. Moreover, it optimizes the use of traditional resources. Therefore, this agricultural management system contributes to the development of sustainable agriculture; allow solving both economic and ecological problems, which are becoming more acute. Research on precision onion and garlic production technology is in progress across the globe.

Field preparation: Field preparation namely ploughing, tilling, intercultural operations, levelling, organic manure spreading and bed formation are almost 100% mechanized. These machines are used more precisely for these operations both in onion and garlic cultivation.

Precision onion/garlic seed planter: Generally, onion and garlic crops are sown at 2 cm below soil surface with plant to plant spacing of 10 cm and row to row spacing of 15 cm. After sowing, the seeds are covered with soil and given light irrigation. This method of sowing/planting consumes more labour, time and require high cost. However, precision onion seed and garlic planters developed by Punjab Agricultural University, ICAR-CIAE, ICAR-IARI, JNKVV, Jabalpur, Jain Irrigation Systems Pvt. Ltd., and several private firms reduce labour cost and cover larger area in a unit time. Development and introduction of this high capacity, precision, reliable and energy efficient planters and their judicious use can bring in the precision and timeliness in field. These precision seed planters are capable of maintaining the row to row and plant to plant spacing, and depth control option of furrow openers to drop the seeds at proper depth. In addition, *kharif* crop occupies main field up to November and provide less time for main field preparation during *rabi* season. Hence, onion transplanting may be good option for rabi season.

Precision onion transplanter: Onion transplanting has always been done manually in India. The major problem with manual transplanting is maintaining uniformity in spacing and proper depth throughout the field. In addition, the number of labour required for this operation is more which increases cost cultivation. Tractor operated onion transplanters are required to overcome this problem. ICAR-CIAE, Bhopal, MPKV, Rahuri, and SP Agro Innovations and several firms are working to develop precision transplanters. SP Agro Innovations has developed a tractor operated onion seedling transplanter. In this transplanter, there is provision for garlic planting and other vegetable crop seedlings as well. The invention has successfully managed to control the flow of seedlings one by one through the loading tray mechanism. It helps to control the spacing between rows and plants. In addition, the beak of machine goes below the soil surface and places the seedlings at certain level below the soil surface so that the seedlings remain upright. Proper row to row and plant to plant spacing facilitates higher air ventilation, mechanical weeding and harvesting in the onion field.

Precision weeder: Many researchers have reported that onion and garlic plants arepoor competitors of weeds. If weeds are allowed freely in onion and garlic and unrestricted then they coulddeprive the onion and garlic yield by 36-48%. Manual weeding in onion and garlic crop is a very tedious, costly and timeconsuming operation due to its closed spacing. ICAR-CIAE has developed onion weeder with a verticalrotary weeding principle which could be easily used in closely spaced crops such as onion and garlic. The weeding efficiency of self-propelled onionweeder is 91-93%. New technologies may allow site-specific weed control which is a central element in integrated weed management. Mechanical weeding by high-precision hoeing to site-specific spraying of annual weeds based on imaging from tractors, ground-based robots (UGV), and unmanned aerial vehicles (UAV) become realistic in widely spaced crops. This technology needs to be developed and adopted in closely spaced crop as well.

Precision irrigation and fertilizer management: Irrigation, integrated nutrient, pest and disease management practices have been developed and recommended to the farmers. However, precision water, fertilizer, pest and disease management is the integration of information, communication, and control technologies in the irrigation process to obtain optimal usage of water resources while minimizing environmental impact. Precision farming techniques takes into account the spatial and temporal soil variation, soil structure and hydraulic properties, plant responses to water and nutrient deficit, changing weather variables through effective monitoring via Internet of Things (IoT), to make better irrigation decisions that have the potential to help achieve high water saving and improved yield. Variable-rate technology (VRT) allows fertiliser, chemicals, irrigation water and other farm inputs to be applied at different rates across a field, without manually changing rate settings on equipment or having to make multiple passes over an area.

Pest, disease and nutrient deficiency management: Nutrient deficiency, insect pests and diseases causes significant yield and quality losses to onion and garlic. Therefore, appropriate nutrient, pest and disease management practices are essential for increasing yield and quality bulbs. Integrated nutrient, pest and disease management practices have developed, validated and recommended to the farmers through All India Network Research Project on Onion and Garlic. In addition, diagnosis of nutrient deficiency, pest and disease attack during growth stages are crucial for correcting these problems and increasing the yield and quality of the bulbs. ICAR-DOGR has generated information and documented data regarding onion and garlic pest and disease symptomatology, epidemiology, nutrient deficiency symptoms and management. Integration of these information with IoT are required for nutrient deficiency identification, pest and disease early warning system, sensor based storage disease management, drone based disease surveillance, image based modelling *etc*.

Drones spraying: Drones (UAVs) are used in agricultural activity to prevent, cure and detect pests and diseases of the crops. Like any other aerial vehicles, UAVs also have pilots, which control the drones from the ground. Drones are attached with different equipment for usage purposes. UAV flown over the farm field captures high-resolution images of any pest, diseases, rogue plant or potential threats to the crop. ICAR-DOGR has initiated research to capture the images for nutrient deficiency, pest, and disease infestation in onion and garlic using the drones. The database of images will be developed, processed and used for precision crop management.

Robotic harvesters: In general, onion and garlic bulbs are harvested manually which requires more labours. Mechanical harvesters have been developed for onion and garlic harvesting. However, the harvesters require modification. About 50-75% onion and garlic bulbs are exposed to the atmosphere at harvesting. Hence, the possibility of using the robots for onion and garlic may be explored. In agriculture robotized harvesters have been used for decades. Harvesting robots were designed for tomatoes, cucumbers, mushrooms and other fruits and vegetables.

Future thrust: However, the precision management tools adopted in onion and garlic production is limited. Research work on precision management of onion and garlic at ICAR-DOGR are in progress. The work has been initiated in collaboration with IIT, Bombay, ICAR-IIHR, and ICAR-IARI.

5.1.6 Advances in precision production systems of flower crops

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Floriculture Industry is part of Lifestyle Horticulture industry that is worth US $ 300 Billion. Floriculture exports per se are valued at USD 8.45 billion which is 0.05% of overall global trade of all the commodities. Flowers are 352nd most traded product in the world in terms of its rank. Flowers are always an integral part of Indian culture. They have been cultivated for aesthetic purposes, as also for their fragrance and extraction of nutraceuticals. The Government of India made various provisions and introduced a variety of incentives helping to establish 100% Export–Oriented–Units (EOU's) resulting in a vibrant floriculture industry in India. Indian floriculture industry, which was hitherto individual driven, became corporate driven during 90's.

Open filed cultivation of traditional flowers still remains the backbone of Indian floriculture with 95% of area out of 305000 ha under loose flowers producing 2301000 MT. Cut flowers are grown in the remaining 5% of the area producing 762000 MT of different cut flowers (NHB 2019-20) Floricultural exports from India comprises of fresh cut flowers (to Europe, Japan, Australia, Middle East and USA) Loose flowers (for expatriate Indians in the Gulf, South Asian Countries) cut foliage (to Europe) Dry flowers (To USA, Europe, Japan, Australia, Far East and Russia) Potted Plants (Limited to very few countries). Out of these components dry flowers contribute a major share to the total export. The floriculture exports which stood at Rs. 63 crores during 1996-97 increased almost 12 times to Rs. 771 crores during 2020-21. The domestic trade which is highly disorganized is valued at Rs.22000-25000 crores.

Phenomenal growth of floriculture sector across the world is primarily attributed to developments in research, proactive policies of the various governments and infusion of precision technologies. In traditional horticulture, farmers apply the same amount of inputs like pesticides, fertilizers, and irrigation across fields, at prescribed times and frequencies, as per the general recommendations for the region. However, precision horticulture targets the intrinsic differences in farmland and optimizes input by Variable Rate Application (VRA). To implement VRA, detailed spatial data must be collected across fields and locations through geographic information systems (GIS) and crop lifecycles using GPS and remote sensing. The precision farming tools used include precision irrigation systems, yield mapping and monitoring tools, besides information management systems. Using advanced descriptive, predictive, and prescriptive analytics engines to analyze the data, precision agriculture arrives at data-driven management decisions to implement cost-effective, environment-friendly sustainable modern farming solutions.

Using emerging technologies like the internet of things (IoT)-enabled devices such as smart agricultural sensors and robotic drones, satellite imagery, and GPS-enabled instruments, real-time data are collected on soil, crop, hyper-local weather predictions, equipment available, and other variables. This is supplemented by inputs from IoT and AI/ML-driven predictive analytics software. This paper highlights some of the recent developments in the field on important floricultural crops across the world.

5.1.7 Precision production of vegetables in tropics for enhanced profitability

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The agricultural practices presently followed may not be sufficient to feed an increasing population. Due to soil destruction the returns from existing agricultural farms are decreasing. Heavy machinery destroys soil structure, and excessive chemicals are wiping out soil biodiversity besides there is erosion of topsoil due to deforestation. To add to this, climate change has made the food supply very insecure. Moreover, conventional farming methods have left many farmers debt-ridden due to high costs of inputs and low returns. The excessive inputs that intensive agriculture relies on are also causing major environmental problems: pollution and climate change. Most fertilizers are lost as they seep into the ground and runoff during rainfall. The nutrient pollution caused by nitrogen and phosphorus causes eutrophication resulting in vast end zones in seas and impacting local water bodies. Around 31% of the greenhouse gas comes from agriculture: 21% of CO_2, 78% of nitrous oxide, and 53% of methane. Carbon emissions arise from fossil fuels used to manufacture fertilizers and pesticides and drive farm machinery. Food loss and food waste together contribute to 8-10% of total carbon emissions. Food loss occurs from farm to retail due to untimely harvest, improper packaging, sorting, transport, and storage. Precision farming can influence a paradigm shift in India's obsolete and aggressive farming practices to digitally transformed agricultural practices. In a developing country like India, precision farming has countless opportunities for farmers to adopt sustainable practices, intensify productivity and augment farm income.

5.2 Oral Presentation

5.2.1 Prospects of precision farming for medicinal plants

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Precision farming, a modern technique that involves the use of advanced technology to optimize crop production, can be applied to the cultivation of medicinal plants. Precision farming offers several benefits over traditional farming methods, including increased crop yields, reduced input costs, and environmental sustainability. Prospects of precision farming of medicinal plants, including the application of soil sensors, remote sensing, and geographic information systems (GIS) to optimize the use of resources and improve crop yields has huge potential. Despite the potential benefits, challenges such as the lack of standardized protocols and the high cost of implementing precision farming techniques are addressed. Standardized protocols, training programs and awareness campaigns can promote the adoption of precision farming techniques for medicinal plant cultivation. The ICAR-DMAPR already has initiated such work in this direction.

5.2.2 Precision agriculture in potato for higher productivity

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Potato is a staple food that contributes to the energy and nutritional needs of more than a billion people worldwide but has often been underappreciated as far as its role in the global food system is concerned. The crop is ideally suited to places where land is limited and labour is abundant, conditions that characterize much of the developing world. The two emerging Asian economies—China and India—together contribute nearly 1/3rd of the global potato production at present. In the recent past, remarkable progress has been made in potato production in China (99 mmt) and India (52 mmt). The opportunities for further development of the potato industry appear to be very good in these countries. Potato is a predominant vegetable in India. At present, most of the domestic supply of potatoes is consumed fresh (68%), followed by processed (7.5%), and seeded (8.5%). The remaining 16 percent of potatoes are wasted due to postharvest losses. As per the projection made by ICAR-CPRI, Shimla, India would require about 125 million metric tons of potatoes annually by 2050. This enormous jump in production has to come from productivity enhancement, since the availability of additional cultivable land for potato cultivation would be virtually nil due to unfavourable changes in land utilization patterns. Precision agriculture (PA) provides the ability to utilize crop inputs more effectively, including farm equipment, seeds and seedlings, fertilizers, pesticides, and irrigation water. With the growing concern for economic viability and environmental sustainability, the use of PA tools like GPS, GIS, UAV models, and DSS is likely to increase. Efficient and effective use of inputs would lead to greater crop yield and/or product quality without polluting the environment. Under PA techniques like VRT for the management of nutrients, water, and pests in the potato crop in India. Spatial variability maps of available nutrients developed for potato growing pockets by ICAR-CPRI can also be a tool to have nutrient recommendations specific to a field rather than using a blanket recommendation for the region. These maps are useful for identifying specific locales of potato growing pockets with different nutrient management problems. The need-based nutrient application for potatoes and the application of DSS in Indian agriculture have been initiated in some places. To utilize the full benefits of PA in Indian conditions, an organized, well-planned, long-term policy suitable for the Indian farming sector is required. At present, aeroponic cultivation of potatoes is considered modern farming of potato tubers. Aeroponics is a soilless method where plants are grown supported at the top with their roots hanging into a box. A solution of nutrients mixed with water is periodically pumped into the box and misted onto the hanging roots. The roots don’t have to be floating in soil or water to stay hydrated and absorb nutrients. In recent years, both aeroponic and hydroponic agricultural systems have gained popularity. Despite the fact that they both do not use soil, the manner in which nutrients are provided to the crops differs. Plants in hydroponics are always kept in water, which is supplemented with nutrients. Nutrients are delivered by spraying water in aeroponic farming.

5.2.3 Production technology of cherry tomato in Bihar as an alternative to conventional vegetable production

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Cherry tomato (*Solanum lycopersicum* var. Pusa Cherry Tomato-1) is a highly priced culinary as well as ornamental vegetable and known as probable ancestor of tomato. It is more closely related to wild tomato and contains higher beta-carotene over lycopene. It is becoming increasingly popular among common people, who are now interested in garnishing their dishes and diversifying their nutritional intake. Cherry tomatoes look not only attractive in kitchen gardens but are commercially valuable horticultural commodity and have impressive nutritional and pharmaceutical properties. The characteristic property of cherry tomato is the higher fruit quality than that of standard tomato fruit, but this crop is not widely cultivated in India.

The present investigation was conducted to study the effect of NPK levels on the nutrient contents in soil and plant and on yield and quality of cherry tomato. In order to investigate, 5 different treatments (T1 , T2, T3, T4, T5) were chosen and concluded that the maximum nutrient contents in the fruit, shoot and root were found in the treatment comprising of 125 % RDF (T5) followed by 100% RDF (T4) and minimum values were found in the treatment (T1) control. The quality parameters of cherry tomato have been found to significantly vary with the extent of fertilizer doses applied. The maximum fruit size (4.55 cm^2), fruit weight (10.40 g) and TSS (9.70 °Brix) was found in T5 comprising of 125 % RDF followed by T4 (100% RDF) where as the minimum values for these parameters were found in (T1) control where no fertilizer was applied. The fruit yield of 1.95 kg per plant (495.60 q ha-1) was also recorded under T5 followed by T4 with a total yield of 435.10 q ha-1. The BC ratio of 8.59 was also highest for T5 (125 % RDF). So, cultivation of cherry tomatoes can be a lucrative alternate for generating farmers' sustainable income.

5.2.4 Relationship between horticultural and the Biochemical Traits in Garlic (*Allium sativum* L.)

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Garlic (*Allium sativum* L.) is considered as one of the most important species in onion family, Amaryllidaceae. Garlic is a source of various biologically active phytomolecules, including organosulphur compounds, phenolic acids, flavonoids, vitamins and nutrients. The study was conducted at Vegetable Research Farm, Department of Horticulture, Bihar Agricultural University, Sabour, Bhagalur during Rabi season with the objective to study correlation among yield and yield attributing characters and the biochemical traits. The experimental material consisted of 25 garlic genotypes from different locations

in India. Experimental trial was laid out in a RBD with three replications. Analysis of variance was done by the method suggested by Panse and Sukhatme (1967). The observations were recorded on five randomly selected plants of all genotypes for horticultural traits like plant height, number of leaves, leaf length, leaf width, pseudostem length, neck thickness, polar diameter, equatorial diameter, and average bulb weight and biochemical parameters like TSS, ascorbic acid, total carotenoids, total phenolic content, total flavonoids and antioxidant capacity, Radical scavenging activity and metal chelating activity, nitrogen%, phosphorous%, potassium%, sulphur% and protein%. Analysis of variance indicated significant differences among the genotypes for all the characters under study which implied a considerable amount of genetic variability in the genotypes included in the study. Correlation coefficients were computed at genotypic and phenotypic levels between pair of characters adopting the formula given by Al-Jibouri *et al*. (1958). Path analysis was worked out by using the estimates of correlation coefficient in all possible combinations among the dependent variables using the techniques given Dewey and Lu (1959). The perusal of data revealed that in all the characters under study, the genotypic correlation coefficients were higher than their corresponding phenotypic correlation. In the present findings garlic bulb yield was genotypically and phenotypically significantly positively correlated with length of leaf, breadth of leaf, number of clove per bulb, polar diameter, weight of clove, ascorbic acid and sulphur content. Path coefficient analysis of the different characters revealed that that average weight of clove had highest direct positive effect on yield followed by number of cloves per bulb, polar diameter of bulb, nitrogen% , phosphorous%, potassium%, plant height and sulphur%.

5.2.5 Stability analysis for yield, yield component and essential oil content in coriander (*Coriandrum sativum* L.) under long-term organic production system

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The stability of eight released varieties of coriander (*Coriandrum sativum* L.) was evaluated for yield, yield attributes and essential oil based on six consecutive years of field trials during 2016 - 2021. The mean square due to environment + (variety × environment) was found significant for all the traits studied, indicating the existence of variety × environment interaction. Based on the mean performance, regression coefficient and deviation from regression values, it was found that the stability of yield and yield components are imparted in the varieties, ACr-1 and Azad Dhania-1 across the years through the stable performance of characteristics like numbers of primary and secondary branches, numbers of umbels and umbellate, seed yield and essential oil content. Based on the findings coriander growers are apprised to select stable high yielding coriander varieties for the organic production system in the semi-arid regions of India. In addition to stability, principal component analysis (PCA) indicated that only two principal components showed 79% of the total variability. The highest value of yield and its attributing traits were present in PC1 & PC2 respectively. Euclidian distance-based cluster analysis grouped all the genotypes in two major clusters according to their stable yield and quality attributes. Hence these two varieties ACr-1 and Azad Dhania-1could be used in hybridization programmes to converge the stability characteristics of seed yield for the development of a stable variety adapted to a wider range of environments under organic production systems, these varieties could also be included in the seed spice-based cropping system for sustainable yield.

5.2.6 Evaluation of marigold genotypes for growth, floral and seed production under gangetic plains in Bihar

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Floriculture is a centuries old agricultural activity in India which represents beauty, calmness, elegance, love and purity. Among various floricultural crops, marigold (*Tagetus*spp.) is one of the most important flower crop grown commercially for loose flowers in different parts of India. In Bihar, it is grown as loose flower and for decoration and landscaping purposes, but due to meager research work on marigold, information for commercial varieties is lacking. Therefore, present investigation was carried out at department of Horticulture (Veg. and Flori.), BAC, BAU, Sabour during 2021-22 to evaluate twelve genotypes of marigold under Bihar conditions in Randomized Block Design (RBD) with three replications.The experimental results revealed that there were significant differences among all genotypes for various growth,floraland seed attributes. Among all genotypes, Hisar Jafari-2 recorded maximum flower yield per plant (676.87 g), plant spread (75.45 cm), leaf biomass (1745.61 g), number of primary branches per plant (26.67) and number of secondary branches per plant (62.26).Genotype Sutton Yellow recorded maximum average fresh weight of leaf (1.54 g)and stem diameter(0.68 cm), second maximum value for leaf biomass (845.71 g) and number of flowers per plant (66.96). Genotype Pusa Narangi Gaindaobtained maximum flower duration (107.22 days), weight of seeds per peduncle (0.71 g) and seed yield per plant(134.98 g), second maximum value for plant height (71.31 cm) and number of primary branches per plant (20.11) followed bythird maximum value for plant spread (57.15 cm). Genotype Crackerjack noticedearliest days taken to first bud initiation (31.78 days), maximum values for plant height (72.19 cm), flower peduncle length(2.16 cm), weight of seeds per peduncle(0.69 g) and seed yield per plant (108.69 g) followed by second maximum value for plant spread(69.43 cm) and number of secondary branches per plant (55.34).

5.2.7 Heritability, variability and correlation, path coefficient analysis in marigold

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In India, marigold (Tagetes spp.) was introduced by Portuguese and became popular in India due to wider adaptability to varying climatic and soil conditions. It is the top most loose flower of north India and is associated with festive occasions, marriages, religious ceremonies and social functions due to good keeping quality. Besides its pristine uses, marigolds are economically used as cut flower for interior decoration, in hanging baskets, rock gardens for landscaping purposes. Keeping these points in consideration, twelve marigold genotypes were evaluated under Bihar condition during the year 2021-22. The PCV estimates were greater than GCV with respect to all the twenty one traits. High level of GCV and PCV were recorded for seed yield per plant (GCV=99.59%, PCV=99.93 %) followed by leaf

biomass of flower (GCV=93.55 %, PCV=94.23 %), number of leaves per plant (GCV=89.05.18 %, PCV=89.68%) and flower yield per plant (GCV=75.82 %, PCV=76.33 %). High heritability together with high genetic advance as per cent of mean was recorded in 100 seed weight (99.81 %,95.59 %), average fresh weight of leaf (99.69 %, 95.13 %), average fresh weight of flower (99.67%, 136.67%), weight of seed per peduncle (99.59 %, 112.47%), number of seed per peduncle (99.45 %, 120.26 %), seed yield per plant (99.35 %, 204.51 %) and days taken to first bud initiation (99.33 %,76.13 %), Based on correlation coefficient, number of flowers per plant (0.609, 0.608) and average fresh weight of flower (0.801, 0.799) were recorded highly significant and positive correlation with flower yield per plant,whereas stem diameter (0.391, 0.390) had significant positive correlation with flower yield per plant at phenotypic and genotypic level, respectively. Based on path coefficient analysis characters like number of flowers per plant (0.715, 0.716), number of leaves per plant (0.858, 0.856) and average fresh weight of flower (0.708, 0.708) had direct positive effect towards flower yield per plant at both phenotypic and genotypic level, respectively.

TECHNICAL SESSION-6

PRECISION AND SPEED BREEDING FOR HARNESSING POTENTIALITY FOR CLIMATE RESILIENCE AND SUSTAINABILITY

6.1 Keynote Lectures

6.1.1 Demand driven vegetable breeding: opportunities and challenges

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The traditional breeding methods often follow a supply-driven approach, where breeders focus on developing new varieties based on what they think will sell. This approach may result in overproduction of some crops and underproduction of others, leading to market inefficiencies. Demand-driven breeding (DDB), on the other hand, aims to develop varieties that meet specific consumer needs and preferences. In this article, we will explore the opportunities and challenges of demand-driven vegetable breeding.Demand-driven breeding allows breeders to develop varieties that meet the specific preferences of consumers.For example, if consumers prefer sweeter tomatoes, breeders can focus on developing varieties with higher sugar content. This will increase consumer satisfaction, which will lead to increased demand and eventually, higher profits for farmers. Breeders candevelop varieties that meet the specific demands of farmers.For example, developing varieties that are more resistant to pests and diseases, or by breeding for crops that have longer shelf lives. This can help reduce the amount of produce that is wasted due to spoilage or damage during transport. Furthermore, breeding for traits that are important to consumers, such as taste and nutritional content, can lead to a more diverse range of crops being grown. This can help improve soil health and reduce the need for fertilizers and other inputs, ultimately leading to a more sustainable agricultural system. However, no breeding process is without challenges,soDDB could be expensive as it requires a significant investment in research and development.Breeding programs often have limited resources (germplasm and manpower), which can make it difficult to focus on both traditional and demand-driven approaches. As a result, DDB may not receive the attention it needs to be successful.Breeding new varieties takes time, often taking several years to develop and test. This can make it difficult to respond quickly to changes in consumer demand or market trends.In conclusion the DDB has potential to improve efficiency, sustainability, and profitability of the vegetable sector. By breeding varieties that meet consumer preferences, breeders can help reduce waste, improve sustainability, and increase consumer satisfaction. However, demand-driven breeding also presents several challenges, such as high costs and limited resources. To overcome these challenges, breeders must work closely with farmers, retailers, and consumers to ensure that their breeding programs meet the needs of all stakeholders.

6.1.2 Advances in precision production of oil palm with special reference to speed breeding

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Oil palm (*Elaeis guineensis* Jacq.) is a cross-pollinating, monoecious, and perennial crop belongs to the family Arecaceae. The world population is expected to be over nine billion by 2050, and the demand for palm oil also expected to be in the same trend between 120 and 156 million tons. The availability of large genomic data in the open domain leads to pioneering approaches in identification of new genes for speed breeding approaches in developing high yielding oil palm cultivars. In the present review, following approaches were discussed for rapid breeding of several traits with the genomic technologies can resolve the issue of high yielding cultivars in a short time.

6.1.3 Variable physiological and molecular responses in two banana genotypes against drought, heat and their combination

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Distinct drought and heat stresses create demonstrative impact on growth, development and productivity of crops and their combination decreases the crop productivity even further. We have compared physiological and molecular responses of two contrasting banana genotypes, Grand Nain (GN, AAA genome) and Hill banana (HB, AAB genome), under individual drought, heat and their combined stress under controlled as well as in open field conditions. Combined drought and heat stress caused 100%

yield loss in GN; however the yield loss was only 46% in HB. Individual drought and combined stress caused higher reduction in leaf relative water content, increased ion leakage and H_2O_2 content in GN plants as compared to HB plants. However, individual heat stress resulted in minimum changes in physiological parameters. Further, the expression of *DREB* (A-1 and A-2 group) and stress responsive *NAC* genes revealed higher background molecular responses in leaves of HB plants for individual stresses as compared to GN plants. However, a combination of heat and drought stress suppressed their expressions in HB but activated them in GN. Interestingly, the expression of the *DREB* and stress responsive *NAC* genes was blocked in the drought tolerant HB even when subjected to combined drought and heat stress in the field, unlike in GN. Most of these genes were strongly up-regulated within 30–60 min upon application of exogenous abscisic acid (ABA) and the increase was prominent in GN. This response in HB was associated with better stomatal control over transpiration thus avoiding the need for stress pathway activation unlike in GN. The study suggests that the B genome in the stress-tolerant HB may be responsible for tolerating more drastic combined stresses without taking recourse to the expression of *DREB* (A-1 and A-2 group) and stress responsive *NAC* genes.

6.1.4 Precision breeding in cucurbits for climate resilience

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Cucurbitsoccupies nearly one-fifth of the total vegetable production in India and an important component for livelihood of millions of small and marginal farmers.Cucumber and melons are two important Cucurbits from Asian origin and being widely cultivated in India and worldwide. The genomic information in these two crops was made available early so that many genomic tools could be utilized for improvement of many traits in these crops in India also.Indian cucumber cultivars exhibited mainly monoecious sex expression coupled with crown fruit inhibition which is supposed to be the main reason for lower productivity. Gynoecism has been extensively exploited in heterosis breeding for enhancing productivity of cucumber worldwide but exotic gynoecious lines were not stable at higher temperature and they possessed very few lateral branches which were not suitable for open field condition. The F2 mapping population was developed using the Indian monoecious cultivar of light-green-fruited Pusa Uday as the recurrent parent and the American gynoecious pickling line G421 as a donor. Two markers, SSR13251 and SSR15516, were found to be closely linked to the F locus at 1.5 and 4.5 cM, respectively, by marker analysis of F2 individuals. The IBLs were developed by backcrossing Pusa Uday with BC1 and BC2 progenies followed by foreground and background selection of plants displaying the gynoecious habit in the background of Indian slicing cucumber.Seven QTLs for gynoecism were detected in two genomic regions (chromosome 5 and 6) on which three significant QTLs (qGyn 5.1, qGyn 6.5 and qGyn 6.6) had higher LOD score (10.5, 26.2, and 24.5) and phenotypic variance (5.9, 14.5 and 14.5%) in BC1F2 population. However, two significant QTLs (qGyn 5.1 and qGyn 6.1) accounted for gynoecism which could explain 22.90 and 12.88% of the phenotypic variation with the LOD score of 15.86 and 11.82.Novel source of Fusarium wilt resistance from Indian melon germplasm was identified from DSM-11 and TOLCNDV resistance was identified from *Cucumis melo* var. *momordica* accessions DSM-132 & DSM-19. Snap melon fruits are associated with inferior fruit quality traits like very low sugar content (TSS<4) and undesirable fruit flavor which makes it a challenging job to transfer resistance gene from snap melon to muskmelon without compromising the fruit quality traits including its unique flavor and Total Soluble Solid (TSS) content (>12) which is a measure of sweetness as well as market

acceptability. Introgression of gene from wild relative involves a substantial breeding efforts including screening against the pathogen in severe disease pressure in field condition to follow the resistant offspring plants in each successive generations. Based on fruit quality traits and resistance to Fusarium wilt, selections were made from backcross population of (Kashi Madhu X DSM-11-6) and characterized with validated molecular markers for presence of Fom-2 gene. For mapping of ToLCNDV resistance gene, 3 CAPS primers were designed from position interval of ToLCNDV QTL in chromosome 11 between D14 and D23 markers and 1 CAPS marker could be identified for association with susceptibility factor. Novel monoecious line (DMM-31) of muskmelon with round fruit and excellent fruit quality was developed which will be utilized for easy and economical hybrid seed production. Few QTLs for different fruit quality traits could be identified which will be a valuable source of information for future muskmelon improvement programme. New genomic resources and information will be quite helpful for Cucurbits improvement programme in future. Increased selection efficiency through marker assisted breeding (MAB) may be attained through early selection and screening plant population under variable disease pressure or even without the occurrence of disease in the growing environment.

6.1.5 *Cymbidium* Orchid Breeding: history, present status and future prospects

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Artificial hybridisation of cymbidium orchids began in England in the late nineteenth century. The first artificial Cymbidium hybrid, *C. Eburno-lowianum* (*C. eburneum* x *C. lowianum*), flowered in 1889 in the nursery of James Veitch & Sons in England. In the early years, the gene pool consisted of a few species such as *C. tracyanum*, *C. eburneum*, *C. lowianum, C. hookerianum*, *C. mastersii* and *C. giganteum* (*C. iridioides*). These species limited the improvement of colour and size, but the introduction of *C. insigne* brought a big change in breeding of cymbidiums. This species passed on characters like long inflorescence well above the leaves, floriferourness, large and long-lasting flowers to its progenies. *C. Alexanderi* (*C. insigne* x *C. eburno-lowianum*) is one of the most important contributions of this species. In addition, different colour forms of *C. insigne* and *C. erythrostylum* contributed significantly to the development of new hybrids of Cymbidium. The appearance of natural tetraploids, C. Alexanderi 'Westonbirt' and C. Rosanna 'Pinkie', in two diploid grexes, *C. Alexanderi* and *C. Rosanna*, respectively made the beginning of polyploidy breeding in Cymbidium. Soon the importance of polyploidy for breeding was recognised and a number of superior hybrids were converted into tetraploids for use in the breeding programme. The gene pool was further increased by the introduction of miniature species such as *C. pumilum* (*C.floribundum*), *C. devonianum*, *C. madidum* and *C. ensifolium* into the breeding programme and many desirable traits such as fragrance, cascade inflorescence, colour and size were improved. Breeders now use lesser known species and related genera to introduce variability into the cultivated hybrids. Over the years, about 16000 Cymbidium hybrids have been registered with the International Orchid Registration Authority, Royal Horticulture Society, London.

The important traits for cymbidium breeding include compact growth habit, free flowering, rapid growth, multiple flower spikes, upright and self-supporting flower spikes, round flower shape, orientation of flowers on the spike, longevity of flowers, attractive colours including pure colour without sunstaining. The other traits like attractive colour, fragrance, off-season flowering, extension of flowering time and earliness should also be considered. India has a great potential for developing commercial varieties of this orchid with about 21 indigenous species and over 300 introduced cultivars. The present paper discusses the current status of cymbidium orchid breeding in India and identifies constraints and suggests future strategies for breeding this orchid.

6.2 Oral Presentation

6.2.1 Okra breeding: present status and future challenges in India under changing climate

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Okra (*Abelmoschus esculentus* L. Moench), is an important crop of tropical and subtropical regions of India grown for its tender pods that are used in fresh and processed form. Okra is known for its high nutritive value, extensive industrial application, and significant foreign exchange earnings. The Indian gene pool of okra exhibits high genetic diversity for agronomically important traits, which has been exploited to develop a number of improved varieties. A wide range of breeding methods and techniques have been employed to develop high yielding, stress tolerant varieties also keeping consumer preference as priority. Okra breeding in India started with the efforts of Dr. Harbhajan Singh who introduced high yielding varieties and biologically important wild relatives of okra. Later on researchers applied conventional breeding methods such as pure line selection and hybridization based methods for cultivar development. Interspecific hybridization is the go-to method in okra specifically to transfer YVMV resistance from wild relatives, through which several YVMV resistant cultivars were developed viz. Punjab Padmini, Parbhani Kranti, Arka Anamika etc. Heterosis is exploited to evolve hybrids that are very much popular due uniformity, high yield, earliness, stress tolerance and wide adoptability. To make hybrid seed production cost effective, alternatively Genic Male Sterility (GMS) system has been developed. Now a day due to climate change okra production may hamper significantly due to more severe effect of biotic and abiotic factors. Okra is more sensitive to low temperature as compare to high temperature during early growth stage. The abiotic factors influence the severity of pests and diseases in okra which causes severe yield losses. Therefore, for maintenance of sustainable production, researchers have to invent some eco-friendly technology in near future to overcome negative effects of these several climatic factors. Therefore, in future we have to utilized conventional as well as molecular techniques, like chromosome engineering, RNA interference (RNAi), marker-assisted recurrent selection (MARS), genome-wide selection (GWS), targeted gene replacement, next generation sequencing (NGS), and nanobiotechnology to provide a rapid way for okra improvement in future and also to mitigate the problem of climate change.

6.2.2 Study of metabolites and genetic variability for Growth, yield and proximate compounds in nigella (*Nigella Sativa L.*)

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An experiment entitled "Study of Metabolites and Genetic Variability for Growth, Yield and Proximate Compounds in Nigella (*Nigella Sativa L.*)" was conducted at Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the year 2019-2022. Thirty eight Nigella genotypes along with the check variety AN 20 were evaluated for growth, yield, quality and proximate compounds. Nature of variability, correlation between yield and other traits, genetic diversity for yield and accumulation of metabolites, quantification of thymoquinone and anticancer activity of the crude extract and isolated thymoquinone by cell line studies were conducted. It was observed that the genotypes differed significantly for all the studied traits and the genotype NSC 1 has recorded highest number of capsules plant^{-1} (74.19). capsule weight (16.18 g), capsule length (15.83 mm), capsule diameter (10.76 mm), number of seeds capsule^{-1} (106.06) test weight (2.52 g), plant dry weight (40.81 g), seed yield plant^{-1} (12.90 g), seed yield plot^{-1} (476.60g). Further, the genotype AN 13 performed best in terms of total oil (8.95 %), metabolites viz., total phenol content (4.83 mg GAE^{-1} seed), flavonoid content (34.92 mg QE 100g^{-1} seed(, condensed tannin (42.50 μg CA mg-1 of seed) antioxidant activity (91.77 %) and crude fibre (5.75 %).

6.2.3 Novel gladiolus hybrids for better market acceptability and sustainable production

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Gladiolus is a popular bulbous flower crops grown in open field conditions and used commonly for targeted flower production. A well-rested corm gives the certain production of flower in 70-90 days after planting. In the market there are preferences for white and yellow coloured varieties of gladiolus. Presently most of introduced varieties are used for cultivation. Therefore looking into importance of developing indigenous varieties of gladiolus ICAR-DFR, Pune has initiated breeding work on development of novel gladiolus hybrids. The result of that now we have released DFR-GLAD-01 and DFR-GLAD-03 based on the traits accepted in the market. Hybrid 'DFR-GLAD-01' produces pale yellow (18C as per R.H.S colour chart) coloured florets with reddish spots at the base of inner tepals on background of pale yellow coloured florets make it more attractive. Hybrid having taller plant with 107.58 cm plant height, longer spikes (91.23 cm), took only 48.12 days for spike initiation with more number of florets per spike (15.38). It has good rachis length (48.12 cm) on which flowers arranged in symmetrical manner. The hybrid 'DFR-GLAD-03' produces creamish yellow (18C as per R.H.S colour chart) coloured florets with light yellow coloured inner tepals makes it more attractive. The plant height recorded was 96.87 cm. The hybrid started spike initiation in 63.66 days with robust and compact

spikes. Florets are arranged in two rows with semi-upright position having long spike (81.97 cm), longer rachis length (47.24 cm) and more number of florets per spike (15.81). The florets are ruffled with undulating inner and outer tepals and compact with 9.61 cm diameter. Both these hybrids are having higher propagation rate which is most desired trait for sustainable production of gladiolus.

6.2.4 Performance of gynodioecious line of papaya for yield and Papaya Ring Spot Virus (PRSV) tolerance under field conditions

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Papaya is the third most cultivated tropical fruit crop world-wide. Presently there are dioecious varieties like Pusa Nanha, Pusa Delicious, Pusa Majesty, CO1, CO2, and gynodioecious varieties like Coorg Honey Dew, Arka Prabhath, CO7, Red Lady etc. Most of them are susceptible to Papaya Ring Spot Virus (PRSV). This virus disease is one of the major impediments in papaya cultivation, withrecorded yield loss in the range of 80 to 100%; and has threatened commercial cultivation across the globe. It is transmitted by a number of aphid species in a non-persistent manner with a limited host range of cucurbits and papaya. The various options for managing viral diseases are vector management, planting in areas with negligible/less virus-inoculum, rogueing, and host-plant resistance. Vector control for managing PRSV is not an economically viable option since the virulent aphid vector transmits the virus within seconds. Growing dioecious varieties is less profitable due to the occurrence of male plants. Till date, there is no gynodioecious variety resistant/tolerant to PRSV. Therefore keeping in mind with both the problems, our objective was to breed gynodioecious lines having tolerance to PRSV along with good yield and fruit quality. IARI Regional Station, Pune has been working for development of gynodioecious lines (PS-2-1, PS-3-1 and PS-5-1). These lines being in process of stabilizing were found tolerant to PRSV. These lines were evaluated with national check Red Lady at experimental farm of IARI, Regional Station, Pune during 2021-2022 and it was found that PS-2-1 performed better in most of the traits. The column length (37cm), average no. of fruits (21) and yield per plant (19.78kg) were maximum in PS-2-1. The fruit weight is around 1 kg which is optimum for marketing preference. It has TSS around 8-9 °Brix and disease severity was 63% in comparison to Red Lady (100%). The line PS-2-1 has good potential as virus tolerant papaya line with acceptable horticultural traits.

6.2.5 Genetic variability, heritability and correlation studies in bulb onion (*Allium cepa* L.) in Jalgaon (Maharashtra) condition

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Genetic variability, heritability and correlation were studied for 13 traits in 39 white and red onion genotypes. A significant amount of variability was observed for all the characters under study. Magnitude of the genotypic coefficient of variance was lower than the phenotypic coefficient of variance for all the characters studied and the difference is narrow suggesting there was less environmental control and greater role of genotype in expression of these characters. All the characters studied had a high magnitude of heritability which suggests that these are highly heritable from parents to their offspring in the next generation and for improvement in these characters selection may be useful. High heritability with moderate genetic advance as percent of mean (GAM) was observed for the characters like plant height, number of leaves per plant and total sugar content which revealed greater role of non-additive gene action in their inheritance where only selection may not be effective and can be improved by heterosis breeding. High heritability coupled with high GAM was observed for other characters under study which indicates the major role of additive gene action and these traits may be improved further by imposing selection. The genotypic correlation coefficient is higher than the phenotypic correlation coefficient for most of the characters indicating little influence of environment. Average bulb weight had positive and highly significant association with plant height, number of leaves, bulb diameter and yield per hectare which revealed that selection based on these traits would ultimately improve the bulb weight consequently the yield and it is proposed that, for getting high yielding segregants, the hybridization of genotypes having combination of above characters is useful. Neck thickness is significantly negatively correlated with plant height but significantly correlated with bolting. Reducing sugar content is positively while non reducing and total sugar content is negatively correlated with neck thickness and bolting. TSS and pungency were strongly associated with each other, while they both were significantly negatively correlated with neck thickness and bolting.

6.2.6 Breeding for development of F_1 hybrids in onion through male sterility

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Onion is one of the pioneer crop in which heterosis has been reported for yield and other economic characters. However, in India, at present no commercially viable onion hybrid is available. ICAR-DOGR has started research work on development of stable high yielding F_1 hybrids in onion with earliness and uniformity in bulb traits. A total of 110 F_1 hybrids of red onion were developed using five male sterile lines (MS 48A, MS 65A, MS 111A, MS 222A and MS 1600A) in crosswith selected twenty-two elite lines as pollinators *viz.*546-DR, 571-LR, KH-M-1, KH-M-2, RGP-1, RGP-2, RGP-3,

RGP-4, RGP-5, 1604, 1605, 1606, 1607, 1608, 1609, 1612, 1613, 1629, 1630, 1657, 1663 and 1666.These F_1 hybrids along with their parents and checks were evaluated during *kharif*, *late kharif* and *rabi* seasons. Sixteen F_1 hybrids *viz.*, DOGR Hy-1, DOGR Hy-2, DOGR Hy-3, DOGR Hy-4, DOGR Hy-5, DOGR Hy-6, DOGR Hy-7, DOGR Hy-8, DOGR Hy-50,DOGR Hy-56, DOGR Hy-73, DOGR Hy-155, DOGR Hy-156, DOGR Hy-172, DOGR Hy-173 and DOGR Hy-179 were found promising. The bulb colour of theseF_1 hybrids are light red to dark red with globe to flat globe shape. However, selected 8 F_1 hybrids *viz.*, DOGR Hy-56, DOGR Hy-73, DOGR Hy-155, DOGR Hy-156, DOGR Hy-172, DOGR Hy-173 and DOGR Hy-179 are presently being evaluated at various locations through AINRPOG. Although all hybrids had good storability, early maturity and free from doubles and bolters, three hybrids namely DOGR Hy-156, DOGR Hy-173 and DOGR Hy-179 were the best in respect of these characters. Heterosis breeding provides an opportunity for improvement in productivity, earliness, uniformity and yield attributing characters. Hence, ICAR-DOGR has developed stable high yielding F_1 hybrids with earliness and uniformity in bulb characters for more yield as well as more income and suitable for precision farming.

6.2.7 Improvement of Okra for Yellow Vein Mosaic Virus (YVMV) and Enation Leaf Curl Virus (ELCV) tolerance

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India is the largest producer of okra in the world. In India, a number of superior cultivars and even hybrids of okra are available for cultivation, with a productivity ranging between 15-20 tons/ha. But the major limitation to achieve the optimum yield are the diseases such as YVMV and ELCV, which is transmitted by the whitefly (*Bemisia tabaci*) and reported to be one of the most destructive plant diseases in India causing great loss by affecting quality and yield of fruits, and crop loss can be up to 90% depending on age of plant at the time of infection. A total of 91 okra genotypes were evaluated at BAU, Sabour out of which only 6 genotypes (IIHR123, IC90381, CI140982, IC141065, IIHR1, Kavya) were expressed high degree of field tolerance against YVMV. In this direction BAU, Sabour has further procured 50 diverse okra genotypes including donor wild species *i.e*., *A.tuberculatus, A. Ficulneus* and *A.moschatus* from ICAR-NBPGR, New Delhi, ICAR-IIHR, Bengaluru and BCKV, Kalyani during this year (2023). These genotypes will be screened and thereafter used for hybridization programme at the experimental field of the college for development of new okra high yielding genotypes along with tolerance against YVMV and ELCV diseases, especially for Zone-IIIB of Bihar.

6.2.8 Advances in breeding for chilli leaf curl disease (ChiLCD) tolerance

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India is one of the main contributors to chilli production and its export worldwide. India shares nearly 43% of the total global area of chilli cultivation. Viruses are the major constraints in chilli production across the globe because, at present, nearly 75 viruses are known to infect chilli crop, of which 37 species are recognised by the International Committee on Taxonomy of Viruses and six are tentative species. In the recent past, chilli leaf curl disease (ChiLCD) has emerged as a serious constraint to chilli production in the India. ChiLCD is caused mainly by Chilli leaf curl virus (ChiLCV) (Family: Geminiviridae, Genus: Begomovirus). ChiLCV shows a widespread occurrence in most of the chillies growing regions. The virus genome is a monopartite circular single-stranded DNA molecule of 2.7 kb and associated with *á* and *â*-satellites of 1.3 and 1.4 kb, respectively. The virus genome is encapsulated in distinct twinned icosahedral particles of around 18–30 nm in size and transmitted by *Bemisia tabaci*. Recently, bipartite begomovirus has been found to be associated with leaf curl disease. For resistance breeding, the reason for the inaccessibility of prominent resistant/ tolerant lines is the lack of a robust screening method for the identification of resistant lines and the evaluation of inheritance patterns. Moreover, advance molecular breeding techniques holds the key to the identification of robust resistance/ tolerance sources and further introgression to elite lines. The genomics-assisted breeding tools helps in the development of high yielding, superior quality along with ChiLCV resistance genotypes.

6.2.9 Use of rapid screening methods for detecting heat tolerant hybrids of coconut (*Cocos nucifera* L.)

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Coconut (*Cocos nucifera* L.) is an economically important palm in most of the South Asian countries including India. It is mostly grown in coastal areas and hilly terrain which is highly vulnerable to climate change. Heat and drought stress are the main impacts of climate change on coconut production. Therefore, development of heat and drought tolerant coconut cultivars has been recognized as a major adaptation measure to climate change. Plant reproductive organs are more vulnerable to changes in short periods of stress during early stages of flowering. Several recent studies have used the in-vitro pollen screening techniques to study the pollen germination and pollen tube growth under different temperatures to evaluate the genotypes for high temperature tolerance. Hence the present study was carried out to identify the effect of temperature on pollen germination and pollen tube growth of coconut hybrids to increasing temperature from 15°C to 50°C. Eight Dwarf x Tall coconut hybrids (COD x ADOT, COD x WCT, COD x LCT, COD x WAT, MYD x ADOT, MYD x WCT, MYD x LCT and MYD x WAT), were selected for the study which are being maintained at ICAR-CPCRI, Kasaragod.

The experimental design was Randomized Block Design (RBD). Maximum pollen germination (38%) and pollen tube length (773µm) was observed at 25°C and least at 50°C. Mean cardinal temperatures calculated from the bilinear model to describe the response of different hybrids to temperature for pollen germination and pollen tube length. Cardinal temperatures (T_{min}, T_{opt} and T_{max}) of pollen germination and pollen tube length varied among the eight hybrids. T_{max} for pollen germination and T_{opt} for pollen tube length were the most important parameters in describing varietal tolerance to high temperature. T_{max} for pollen germination of the most tolerant and less tolerant hybrids were 50.5 °C and 46.1°C, respectively. T_{opt} for pollen tube length in the most tolerant and less tolerant hybrids were 26.9°C and 20.4 °C, respectively. COD x ADOT is the most tolerant hybrids to high temperature stress based on cardinal temperatures for pollen germination and pollen tube length. This type of pollen characteristics will provide useful insight into the reproductive tolerance of coconut to anticipated climate change.

6.2.10 Performance of banana mutant (TBM - 9) under Jalgaon condition

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Field experiment was conducted to study the performance of banana mutant TBM - 9 under Jalgaon conditions at Banana Research Station, Jalgaonduring 2021-22 with respect to dwarfness and yield. The experiment was set in Randomized Block design with three seven replications which. The treatments were comprised of TBM– 9 (T_1), Phule Pride (T_2) and Grand Naine (T_3) and each treatment had unit of five plants. Results revealed significant varietal differences for all the parameters studied exceptdays taken to harvest from flowering, acidity, shelf life and CMV disease. With respect to growth characters, mutant TBM-9 (T_3) recorded significantly the lowest pseudo stem height (163.0 cm) and pseudo stem girth (62.4). However, Grand Naine (T_3)recorded significantly highest number of functional leaves (13.6) and leaf area (13.2) whereas the cultivar Phule Pride recorded least days (237.1 days) for shooting and harvesting (crop duration) (341.5). However, the cv. Grand Nain was on par with Phule Pride for days to shooting (238.2) and harvesting (crop duration) (345.3 days).

In case of yield and yield contributing characters, thecv. Grand Nain (V_3) recorded significantly the highest number of hands per bunch (9.8), number of fingers per bunch (186.0), finger length (21.4 cm), finger girth (12.9 cm), finger weight (154.4 g), pulp weight (96.8 g), bunch weight (21.2 kg) and yield (92.5 mt/ha), thus proving its superiority over TB-9 and Phule Pride. TBM– 9 (T_1) recorded lowest number of hands per bunch (8.9), number of fingers per bunch (136.9), finger length (18.8 cm), finger girth (11.4 cm), finger weight (147.0 g), pulp weight (95.0 g), bunch weight (18.5 kg), yield 82.3 mt/ha).

As regards the fruit quality, thecv. Grand Nain (V_3) had significantly the highest TSS (19.3^{0}B) and also had good acceptability recording 7.4 score. Differences with respect to acidity and shelf life were non-significant.TBM– 9 (T_1) had 16.9^{0}BTSS and had commendable acceptability recording 7.3 score.

No incidence of pseudo stem weevil and rhizome weevil was observed during the period observation. Similarly, all the cultivars were free from cigar end rot, erwinia rot and wilt diseases. However, incidence of yellow sigatoka and CMV diseases was observed. Lowest incidence of yellow sigatoka (12.56 PDI) and CMV (8.0 PI) was observed on the cv. TBM-9.

6.2.11 Development of water positive zone for sustainable ground water management

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Groundwater is the country's most extracted resource with withdrawal rates currently in the estimated range of about 250 bcm per year, thereby putting India on the top of the World's biggest groundwater exploiting nations, being responsible for 25 percent of total global abstraction. The concept water Positive zone means a zone where groundwater pumped is replenished with natural and artificial recharge. This will involve estimation of groundwater pumped, domestic, industrial & agricultural use and estimation of natural recharge and therefore deficit/ over-exploitation. Once this is known the deficit can be met by three-pronged strategy: improve the efficiency in each sector to reduce use, replace use of ground water by recycled treated/ filtered wastewater and artificial recharge. A study of Ground Water Balance, Energy Requirement and Carbon Emission due to groundwater abstraction in RPCAU Campus Pusa was done for four years 2018 to 2022.

The total annual groundwater recharge for the year 2018, 2019, 2020 2021 and 2022was found to be 108.43 ha-m, 140.5 ha-m 194.1 ha-m 221.4 ha-m and, 144.10 ha-m respectively. The annual ground water draft used for water supply was found to be 118.2 ha-m, 122.9 ha-m, 111.9 ha-m, 114.3 ha-m and 117.90 ha-m respectively for the year 2018, 2019, 2020, 2021and 2022 for the irrigation water supply it was found to be 104.8 ha-m, 105.9 ha-m 84.6 ha-m 81.2 ha-m and 99.80 ha-m respectively for the year 2018, 2019, 2020, 2021and 2022.The stage of groundwater use for the year 2018, 2019, 2020 and 2021 was found to be 205.7 %, 162.9 % 101.2 % 88.3 % and 151.1 % respectively.The pumping efficiency increases as the size of the pump decreases. The pumping efficiency varied from 50.2 to 58.5 % for 3hp pump, 37.9 to 47.1 % for 5 hp pump, 29.3 to 31.7 % for 7.5 hp, 24.8 to 25 % for 20 hp and Pump and 23 % for 33hp submersible pump.

The energy requirement for municipal water supply was found to be 239186 kWh, 243770 kWh, 223199 kWh and 208096 kWh 195605 kWh respectively for the year 2018, 2019, 2020 2021and 2022 for the irrigation water supply it was found to be 155572 kWh, 157235 kWh, 125622 kWh and 121504 kWh respectively for the year 2018, 2019, 2020 and 2021. The energy requirement for ground water pumping for municipal water supply was 34.9%, 35.4% 43.7% 41.6% and 31% higher than ground water withdrawal for year for the year 2018, 2019, 2020 2021and 2022 for irrigation water supply. The total carbon emission due to ground water pumping for municipal water supply was found to be 97.2 ton, 99 ton, 90.7 ton 85 ton and79 ton respectively for the year for the year 2018, 2019, 2020 2021and 2022 and for the irrigation water supply it was found to be 63.2 ton, 63.9 ton, 51 ton, 45ton and 60 ton respectively for the year for the year 2018, 2019, 2020 2021and 2022 . The average carbon emission for ground water pumping was found to be 150 ton in which contribution from municipal water supply 93 ton and irrigation water supply was 57 tonrespectively.

Efficient water management strategies like underground pipelines, Micro irrigation systems, protected cultivation, artificial ground water recharge unit, conjunctive use of surface and groundwater and Resource Conservation Technology can help in achieving the goal of water positive zone. The concept of Water positive zone needs to be promoted at the village level for sustainable Ground Water Management.

TECHNICAL SESSION-7

PRECISION MANAGEMENT OF PLANT NUTRIENTS AND WATER

7.1 Keynote Lectures

7.1.1 Micro irrigation in India - An option for precision management of water to enhance productivity

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In India, during the last decade declining water availability to agriculture, has been a matter of discussion, and among various policies and technological packages, water management has received focus for realizing high water productivity. Among various strategies of water management, micro-irrigation proved as success story in many horticulture crops and also in cereals, pulses, sugarcane and cotton. Micro-irrigation technology is bound to maximize the synergistic interactions of improved cultivars, water and fertilizer and could be seen as the congruence of sustainability, productivity, profitability and equity. Since micro-irrigation greatly enhances water, fertilizer and energy use efficiency and promotes precision horticulture, the sustainability could be achieved without the burden of environmental degradation. Horticulture has to gain much for meeting the challenge of more production with declining land and water by adoption of efficient techniques towards high water productivity. Trials conducted on micro irrigation and fertigation on more than 50 Horticultural crops (fruits, vegetables, tubers spices, plantation crops and ornamental crops) have clearly demonstrated a savings of 50-80 % in water, 30-50 percent in fertilizer, 50-100 % enhancement in yield and improved quality of produce besides containment in incidence of the diseases. At present, India has coverage of about 9 million hectares in micro- irrigation with a plan to cover about 69 million hectares by 2030. Institutional support system linked with public and private enterprise and concerted efforts with identified destination involving all the stakeholders keeping the technology at driving seat and farmers as center of attention is bound to have faster and inclusive growth with the policy of per drop more crop, to achieve highest productivity of water. There is success story across the country for enhancing water productivity and enhancing farmers' income across the country. The paper deals with growth and impact of micro-irrigation and also innovations in technology and delivery.

7.1.2 Precision management of water for enhancing water productivity

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Water productivity varies from region to region and from field to field, depending on many factors, such as crop patterns and climate patterns, irrigation technology and field water management, land and infrastructure, and inputs (including labour, fertilizer and machinery). It is found that from 1995 to 2025, the global average water productivity of rice and other cereals will increase from 0.39 to 0.52 kg per m^3 and from 0.67 to 1.01 kg per m^3, respectively. Both the increase in crop yield and improvement in basin efficiency contribute to the increase in water productivity, but the major contribution comes from increase in the crop yield. Moreover, water productivity of irrigated crops, although higher than that of rainfed crops in developing countries, is lower in developed countries. Water is one of the inputs critical to crop growth and yield, both excess and deficit water conditions can cause stress to the crop. Hence, it becomes very necessary to provide with the optimum amount of water to the crop so as to accelerate its yield potential. Precision management of water (PMW) refers to the precise application of quality water at the right time, right place, and right stage of crop growth but uniformly across the selected area.

Farmers in India have been traditionally practicing flow irrigation which is resulting in huge wastage of water, while causing severe soil erosion, leaching of fertilizers, increasing the infestation of pests, diseases and weeds and suppressing the crop yields. Climate change and the approaching water scarcity in the world is very real. Therefore, saving water, by all means, is at the core of farming. The results shown that with laser land levelling farmers could save irrigation water and energy by 24 per cent and obtained 4.25 per cent higher yields. The irrigation cost reduced by 44 per cent over the conventional practice, and water productivity improved by 39 per cent. The returns over variable cost were higher by 1000 per hectare with application of this technology. In sum, laser land levelling has a great potential for optimizing the water-use efficiency of crops without any effect on its productivity. Popularization of this technology among farmers in a participatory mode on a comprehensive scale, therefore, needs a focused attention.

Indian agriculture sector consumes the largest amount i.e. over 85 percent of India's water. To combat the challenges of scarce water, robot and sensor assisted precision irrigation emerges as a solution to reduce water wastage by targeting specific crops and plants.One of the important at feature of agricultural water management is Automation in irrigation. Automation in Micro Irrigation system help irrigator to have better control of farm and irrigation needs as well as peace of mind because the smart system can make decisions independently and operated remotely. Farmer can save a significant amount of water, electricity, time and man power because through intelligent control and automation in the system. Internet of Things (IoT) based irrigation systems offer a variety of advantages over traditional irrigation systems. The systems can optimize water levels based on things such as weather predictions. Additionally, the smart irrigation controller receives local weather data that can help it determine the water requirement of plant. At present, less than 1% of the total area under MIS has adopted the automatic irrigation system due to unavailability of technical expertise and higher initial cost.

In India, there are some challenges to enhance application of robotics and drone in agriculture as less basic data availability, Difficult to measure parameters under most unfavorable conditions,limited internet access and cellular infrastructure. Higher purchase and maintenance costs and resources, the need for skilled operators, In India, field sizes are fragmented. There is potential to improve water use efficiency through smart irrigation systems, especially with the advent of wireless communication technologies, monitoring systems, and advanced control strategies for optimal irrigation scheduling. This paper reviews state-of-the-art smart monitoring and irrigation control strategies that have been used in recent years for irrigation scheduling. From the literature review, closed-loop irrigation control strategies are efficient than open-loop systems which do not cater for uncertainties. It is argued that combining soil-based, plant, and weather-based monitoring methods in a modelling environment with model predictive control can significantly improve water use efficiency.

7.1.3 Retrofitting microbes for nutrients in citrus nursery plants

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Nutritional health of citrus nursery is the foundation of quality production of mature citrus trees coupled with extended productive life. Retrofitting microbes for nutrient requirement one of the novel approaches of not only ensuring good health of citrus nursery but cutting down the intensity of mortalite during planting into new citrus field. We attempted to tailor the nutrient requirement of citrus nursery through the microbial consortium (*Aspergillus flavus,*MF113270; *Bacillus pseudomycoides,*MF113272; *Acinetobacter radioresistens,*MF113273;*Micrococcus yunnanensis,*MF113274; and *Paenibacillus alvei,*MF113275) developed through extensive isolation, characterization and value addition of different microbial inoculants.The progressive microbial response studies showed that the magnitude of response with microbial consortium outweighed the response of individual microbes with regard to large number parameters, comprising germination percentage, vigour index, soil microbial population, changes in available pool of nutrients and leaf nutrient composition, without any additional supplement of inorganic fertilizers. With these efforts, we succeeded in retrofitting microbes in place of nutrients more precisely to be added from outside sources.

7.1.4 Role of customization of nutrients on productivity, quality, soil health & climatic resilience

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Sustainable food production could be impossible without due consideration to depleting soil organic matter, imbalance in fertilizer use, emerging multi-nutrient deficiencies, declining nutrient use efficiency, declining crop response ratio, and negative soil nutrient balance (Das and Mitali 2015).

In the current context, as a part of sustainable agriculture it is very much essential to go for balance nutrition which ensures application of fertilizers on 4R principles (rightratio, right dose,right method&right time) which in turn results in sustenance of soil fertility (physical, chemical, and biological), increase in nutrient use efficiency & avoid nutrient deficiency and toxicities (Kumar and Yadav 2005).

In current scenario, farmers are not adopting balance nutrient concept; the current nutrient ratio varies from 3.5:1.8:1 (MH) to 61.7: 19.2: 1 (Punjab) against the ideal ratio of 4:2:1 which significantly impact on nutrient response ratio (Significantly gone down from 13.4 to 3.7 kg grain/kg NPK).

Horticultural crops vary a great deal in their capacity of nutrient removal pattern depending upon targeted yield. Most of the horticultural crops, (fruits, vegetables, and ornamental plants), due to increased fertilizer prices, growers are concerned about how to improve fertilizer use efficiency ensuring maximum yield and quality improvements. Use of fertigation in fruit crops is reported to save 30-50% of fertilizer doses as well as irrigation (Shirgure and Srivastava 2014, Shirgure *et al*. 2003a).

Balanced nutrient management as per the crops and their stages plays an important role in improving the productivity, quality and saving significant quantity of nutrients. Improving the nutrient use efficiency and balancing the nutrient as per the crop & their specific stages is one of the major challenges. Horticultural crops like Grapes, Tomato, Banana, Pomegranate, Melons, Citrus, and other horticultural crops are very responsive to nutrients through fertigation. However, currently application of most of the nutrients is through bulk fertilizers & through soil application. Fertigation is practiced in few horticulture crops with low dose of nutrients. This is a big bottle neck for productivity and quality of horticultural crops as these crops do not get nutrient as per their stage specific requirement on real time basis.

STL (Deepak Fertilizers & Petrochemicals Corporation Ltd.) has been working on the above objective for the last 35 years. As per STL's experience Nutrient use efficiency (NUE) can be further enhanced by customization of nutrients as per the crops and their stages, by improving the features of the products/solution, through mode of applications in comparison to nutrient application on individual basis.

After understanding these need, SMARTCHEM TECHNOLOGIES LTD (STL) invested efforts in these directions and started R & D and initiated multilocation trials (Maharashtra, Karnataka, Gujarat, Rajasthan etc) in 2018-19 on development of Crop & Stage Specific Customized Water Soluble Fertigation Grades along with complete package in the principle of 20: 80 nutrient ratio (soil vs. fertigation) for Grapes, Tomato Pomegranate, Banana, Melons, Citrus, Potato, Chilli and other fertigated horticulture crops, so as to cater the requirement of nutrients as per the crop's and their stages on real time basis. The basis of this research was Soil Health Status (pH, EC, Calcium Carbonate, OC, Nutrient Status etc), 4R principle, Right form of nutrient, Nutrient partition in the crops, Target Yield and Exportable/premium quality.

STL introduced Crop specific and Stage Specific Customized WSF Grades along with complete nutrition solution in the brand name "SOLUTEK" in 2020-21 for Grapes, Tomato, Pomegranate, Banana after 4 years of extensive multilocation in-house trials & validation through SAUs/ICAR Institutes. Under these Solutek fertigation solutions, 80% nutrients go through three Customized Water Soluble Crop & Stage Specific Customized Fertigation Grades and 20 % nutrients goes through soil applied Enhanced Efficiency Fertilizers boosted with Nutrient Unlock Technology which are mentioned as below:

Customized Water Soluble Grades for Fertigation

1. **Solutek Grapes**: (**Grade-1**: 15:28:06+TE, **Grade-2**: 6:34:17+TE &**Grade-3 :**6:00:37:16+TE),
2. **Solutek Tomato**: (**Grade-1**:17:14:09+TE, **Grade-2**:13:12:19+TE &**Grade-3** : 09:08:28+TE)
3. **Solutek Pomegranate**: (**Grade-1**:08:44:07+TE, **Grade-2**:10:22:20+TE &**Grade-3**: 5:10:35+TE)

   Common basal application: Croptek 9:24:24and Bensulf SUPERFAST (90% Sulphur)

These Solutek grades/solutions are thoroughly tested, validated, and evaluated against RDFthrough straight fertilizers for 2-3 years at ICAR Institute for Grapes (NRCG, Pune), tomato (IIHR, Bangalore) and Pomegranate (NRC, Pomegranate, Solapur), respectively.

Solutek solutions not only increased the productivity & quality of fruits in different crops, but also improved the nutrient use efficiency significantly by saving significant quantities of nitrogen, phosphorus and potash versus existing RDF and common farmer practices. In addition to this, Solutek grades also helped in sustaining better post-harvest soil & petiole nutrient status in comparison to RDF.

- In Grapes,as per two year's study (2020-21 & 2021-22) at NRC Grapes; there is average 17 % increase in yield, two days increase in shelf-life as well as 62% saving in nitrogen dose (99kg/Ha against the RDF-240 kg/Ha in April+ October pruning). These benefits translated into additional income of Rs. 1.56 Lac/Ha over RDF through straight water soluble fertilizers. In STL's inhouse trials, the average increase in yield was recorded to be 27% over farmer practice.
- Solutek Studies of Tomato conducted at IIHR, Bangalore recorded 23% improvement in yield with 11% increase in 'Lycopene' content along with saving of 62 % nitrogen versus IIHR RDF. STL's inhouse trials conducted between 2019 to 2022 recorded average yield increase of 40 % over farmer practice.
- The STL's inhouse Solutek Pomegranate multilocation trials recorded 39% improvement in yield, 26% in fruit weight, 26% in aril weight and 4 % in TSS along with color improvement over Farmer practices.

Overall, 'Solutek Solutions' in horticultural crops are not only increasing farmer's income by enhancing their crop productivity, quality and saving in input cost, but also making their farm operation very easy and convenient because farmers are not required to make difficult decisions every now and then, they don't have to put many fertilizers from many different sources. Over and above these 'Solutek Solution' are improving the NUE significantly hence, saving significant quantity of nitrogen *i.e*. 62-67% along with minimum percentage of Amide Nitrogen. India is committed to reduce its GHG emissions by 30% under the nationally commitment by the year 2030 (MoEFCC, 2019). Seventy seven percent (77%) of the total N_2Oemissionisdueto theapplicationofnitrogenousfertilizers(MoEFCC,2019). Type of Nitrogenous fertilizers and water management impact on climate change because of emission of GHG.Therefore, development of climate smart technologies for mitigation of GHG emissions is the need of the hour.

7.1.5 Precision technologies in seed spice production

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Seed spices are nature's gift to humankind which add taste and flavour to our food in addition to having preservative and medicinal value. Arid and semiarid parts of India (Rajasthan and Gujarat) are known as Seed Spices Bowl and contribute ~80% of total seed spices production. Seed spices are also grown in Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Orissa, Punjab, Karnataka and Tamil Nadu in considerable areas. Among seed spices, the maximum area is under cumin followed by coriander, fennel, fenugreek, ajwain, celery, nigella, dill, anise etc. Being seasonal crops, these are grown extensively in rotation with food crops and also as inter/mixed crops under rainfed/irrigated conditions. Seed spice cultivation is mostly confined to rainfed areas where limited water is available for irrigation resulting in low productivity of seed spices due to the non-availability of water at critical stages. Irrigation efficiency is only to the tune of 30-35%, therefore only means to provide the water is effective management and enhancing the water use efficiency to the level of 80%. So at ICAR-NRCSS, many innovative R&D

initiatives were undertaken to enhance the water productivity and use of available water in an effective manner to get maximum output in seed spices. When, where and how much water should be applied has been worked out by determining the crop-wise critical stage of irrigation, a package of practices, irrigation scheduling and standardization of micro-irrigation and fertigation methods for seed spices. Precision farming, crop diversification, efficient water management, nutrient management practices such as *in-situ* moisture conservation techniques, crop geometry, protected cultivation and plant protection technologies have also been standardized for each crop. Research on vertical farming, sensor-based water management systems and the application of drones is being carried out. In arid and semi-arid areas adoption of precision technologies are very essential for saving precious resources and enhance the livelihood security of seed spice growers.

7.2 Oral Presentation

7.2.1 Assessment of soil chemical properties of Bakhtiyarpur block of Patna district

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A total of 172 representative soil samples from Bakhtiyarpur block of Patna (Bihar) district were collected and analyzed during 2019-20. Under soil chemical assessment it was found that the pH of analyzed soil samples ranged from 6.4 to 7.9 however, EC were in the normal range which varied from 0.44 to 0.99 dSm^{-1}. As far as Organic carbon content of the soil is concerned, it ranged from 0.30 to 0.91 %. The available nitrogen (N) content of the soil varied from 222.18 to 586.0 kg ha^{-1}. Available phosphorus (P_2O_5) content of the soil ranged from 4.0 to 101 kg ha^{-1}. As far as available potash (K_2O) content of the soil is concerned, it varied from 100 to 583 kg ha^{-1}. Soil samples analyzed of Bakhtiyarpur block reveals that pH of about 99 percent of the soils were in neutral range. Nearly 40 percent of the soils of Bakhtiyarpur block were recorded low in respect to organic carbon. About 57 percent of the soils of Bakhtiyarpur block were recorded in medium and 3 per cent in high category in respect to organic carbon. Available nitrogen content was recorded in medium range in about 98 percent of the soil samples of Bakhtiyarpur block analyzed. In respect to available phosphorus content, nearly 30 percent soil samples were recorded in low category, 18 percent medium and 52 percent high category. As far as potash content is concerned, about 2 percent of the soil samples analyzed were found in low category. About 23 percent of the soil samples analyzed were found in medium and 75 percent in high category in respect to available potash.

7.2.2 Exploration of vermiwash for microbial characterization and their application in agriculture

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In an era of increasing nutritional food security and high agricultural output demand, chemical fertilisers and pesticides continue to drive agricultural production. These agricultural practices that have been in use since the green revolution have become obsolete and unsustainable. Chemical fertilisers used in the fields are destroying the ecosystem. These harmful anthropogenic activities are causing a disruption in the biome balance. Maintaining the health of the soil ecosystem, water, and air has thus become a challenge in the current scenario.

However, traditional agricultural practices in India have recently come to light. Organic preparations such as Vermiwash, Panchagavya, Beejamrita etc. have enormous potential for not only increasing agricultural production but also effectively preserving soil and environmental quality. These organic suspensions are a rich source of nutrients for the growth of beneficial microbes. Microflora present in these bio-formulations promotes plant growth and has antagonistic activity against pathogens. PGP microbes thriving in heavy metal induced environment are also a point of research.

Sample collection from Vermiwash and enumeration of microflora was done by using various selective media. Microbial analysis was done by determination of microbial population by using media like Nutrient agar, King's B Agar, Actinomycetes isolation agar. Based on the determination of the microbial population by using different selected media, a total of 4 bacteria were isolated. Morphological properties were identified according to Bergey's Manual of Determinative Bacteriology. Selected bacterial isolates were tested for biochemical and PGP activities. For biochemical characterization, IMViC tests and utilisation of different sugars (kit based) were performed. Bacterial isolates showing remarkable results were selected for plant growth promotory properties like: i) phosphate solubilization using Pikovaskaya agar, ii) Zn solubilization screened on zinc solubilizing agar, iii) K-solubilization was screened on modified Aleksandrov agar medium plates, iv) Siderophore production using Chrome Azurol-S-Agar media, v). Indole Acetic Acid Production Using Salkovaskaya Reagent, vi) Ammonia production using peptone water, vii) Hydrogen cyanide production using King's B media amended with glycine. All those isolates were tested positive for PGPR properties were selected for molecular characterization. Antimicrobial properties of bacteria isolates from formulation were recorded by plate assay method for pathogenic fungus, viz; *C. gloeosporioides* (MTCC 2281) and *F. oxysporum* (MTCC 284). Potato Dextrose Agar was used for the study of antagonistic activity. Bacterial isolates from Vermiwash were tested for their ability to tolerate heavy metals. The chromium heavy metal tolerance was determined by measuring the minimum inhibitory concentration after exposure to increasing concentrations of potassium dichromate salt. Vermiwash was found abundant in the microbial population, which is evident by the CFU on nutrient agar. However, maximum bacterial colony was observed in actinomycetes Agar media ($320x10^6$) and cryema media. ($18x10^6$). Thus, it can be concluded that there is an increased presence of actinomycetes in vermiwash. Bacterial isolates showing phosphorous and potassium solubilizing properties suggest they have good phosphorous and potassium solubilizing bacteria. Bacterial isolates from Vermiwash have shown potential in plant growth promotion, antagonistic activity against plant pathogens, and Cr heavy metal remediation.

7.2.3 Effect of organic source of nutrients on growth, leaf yield and aloin content in *Aloe barbadensis*

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Aloe barbadensis is an important commercial medicinal crop widely cultivated in dry areas in India. It belongs to the family Asphodelaceae (Liliaceae). Its raw materials are used in various formulations and drug manufacturing in the Indian system of medicine. It is widely used in the cosmetic industry for the preparation of shampoo, face creams, skincare, and moisturizing products. A field experiment was conducted at ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand (Gujarat) to study the effect of various organic sources of nutrients management for growth, yield, and aloin content of *Aloe barbadenisns*. The experiment material consists of ten different treatments such as T1: control, T2: RDF (150:150:150 kg NPK/ha), T3: Farmyard manure @10t/ha, T4: vermicompost @5t/ha, T5: castor cake @2.5t/ha, T6: groundnut cake@2.5t/ha, T7: farmyard manure @10t/ha+microbial consortia, T8: vermicompost @5t/ha+microbial consortia, T9: castor cake@2.5t/ha + microbial consortia, T10: groundnut cake@2.5t/ha + microbial consortia. Among the treatments, the application of vermicompost @5t/ha with the combination of microbial consortia recorded a significantly maximum plant height (67.13cm), number of leaves (11.47), maximum number of suckers (10.80) and also produced a maximum sucker yield/plant (6.22 kg). The leaf parameters such as highest leaf length (55.20 cm), leaf width (7.16 cm), leaf thickness (24.86 mm), leaf weight (398.33g), gel weight (269.46g), leaf yield per plant (3.88kg) and maximum latex yield (11.99g) were recorded with treatment T8followed by T10 as compared control (T1).Aloin content in all the treatments was found to be non-significant. The experiment results revealed that the application of vermicompost@5t/ha with the combination of microbial consortia as organic cultivation practices of *Aloe barbadensis* could be beneficial to the herbal farming community to obtain maximum leaf yield and aloin content.

7.2.4 Implications of excess nitrogen fertilizer application on post harvest quality of horticulture produce and human health

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Nitrogen (N) is an essential plant nutrient plays a vital role in cell division; it is found naturally in the environment. In order to maintain a healthy nutritional condition of the crop, inorganic or organic fertilizer has to be applied. In plants nitrogen present in the form of nitrate, it is the most stable

oxidation state. The farming communities moving towards excessive use of nitrogenous fertilizers for better yield and brighter colour of vegetables. The excess use of nitrogen fertilizers leads to increase in nitrate content of vegetables as well as soil pollution and formation of greenhouse gases. The microbes present in the human body converts the nitrate present in the vegetables into nitrites. Nitrates may be considered as the index or precursor to the amount of nitrite which may be formed. These nitrites are responsible for the formation of carcinogenic N-nitroso compounds and may lead to methemoglobinemia. There is widespread concern about nitrate we consume through vegetables and the concern exists as it might prove to be harmful to human health. As per World Health Organization (WHO) the acceptable daily intake of nitrate was 0-3.7 mg/kg body weight. The quality of vegetables mainly depends upon the preharvest and postharvest practices. The preharvest practices such as type, amount and form of fertilizers, harvesting period, growing season and growing conditions influence the yield of the crop and affect its chemical, biochemical, and mechanical properties. The excess N fertilizer application results in undesirable changes like increase in nitrate content, acid to sugar ratio, titratable acidity, carotenes, and vitamin-B_1, on the other hand, decrease in vitamin-C concentration, soluble solids, total antioxidant activity, soluble sugar, polyphenols, Ca and Mg content of different vegetables such as parsley, lettuce, ginger, spinach, cauliflower, and swiss chard. Therefore, application of recommended dosage of nitrogen fertilizer facilitate to produce vegetables with high quality and lower nitrate cotnent with minimal soil and environmental pollution.

7.2.5 Role of Arbuscular Mycorrhizal Fungi (AMF) along with Bio-NPK consortium in optimizing nutrient bioavailability and reducing chemical fertilizers in Maize for maintaining sustainable agroecosystem

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The continuous application of chemical fertilizers in cropping system lead to deterioration of the soil environment as well as air and water and may exert harmful effects on human health. The consumer demand for organic food and export of farm produce has been increasing. The use of chemical fertilizers needs to reduce substantially. The aim of this study was to evaluate the potential of an arbuscular mycorrhizal (AM) fungus formulation containing consortium of three *Glomus* species of endomycorrhizae along with liquid formulation of microbial consortium containing effective strains of nitrogen fixing bacteria, phosphate solubilising bacteria and potash mobilizing bacteria having CFU count 2 x 10^{-8} cell per ml (minimum). The dose of liquid consortium formulation was one liter per acre and for mycorrhiza it was two lakh propagule per acre which was applied with 75% RDF and 50% RDF in randomized block designed in Maize. The results showed that combined application of the bio-fertilizer mixture (nitrogen fixing bacteria, phosphate solubilising bacteria, potash mobilizing bacteria and Mycorrhizae) enhanced maize growth, yield, and nutrient uptake. The 100% RDF treatment, recorded the yield 40.83 q/acre as well as 75% RDF and with 50% RDF along with bio-fertilizer mixture recorded the same yield of Maize which was 41.11 q/acre and40.43 q/acre respectively. The obtained results of bio-fertilization on the growth parameters and yield of maize recommend their use as an alternative tool to reduce chemical fertilizers and this study suggest that integrated nutrient management (INM) are essential to ensure soil fertility and long term sustainable green productivity and we may reduced upto 25 to 50% chemical fertilizers with the help of effective Bio-fertilizers.

7.2.6 Nutrient uptake based NPKS scheduling through drip irrigation system for higher yield and nutrient uptake in onion seed crop

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Onion seed production is currently gaining importance in India and application of mineral fertilizers is essential for increasing the productivity of the crop. According to existing fertilizer application practice, the farmers apply large quantity of fertilizers (25–50% nitrogen and the complete dose of phosphorus, potassium and sulphur) at planting. However, the crop nutrient demand during early growth stages is low and plants require large quantities of NPK and S during the vegetative growth stage (up to 60 days). Application of large quantities of fertilizers before planting is likely to cause nutrient leaching during irrigation, thus making the nutrients unavailable to the plants. Moreover, the application of fertilizers at seed setting and maturity stages is seldom effective for increasing nutrient uptake and seed yield. Fertilizer application should coincide with rapid crop nutrient uptake stage to increase seed yield and nutrient uptake. However, the fertilizer scheduling as per nutrient demand has been standardised. Hence, the field experiment was conducted to study the effect of application of N, P, K, and S fertilizers through drip irrigation system to increase plant growth and yield of onion seed crop. The experiment consisted of five fertilizer treatments namely T1- 100% RDF (100:50:50:30 kg NPKS/ha) through drip, T2- 80% RDF through drip, T3- 60% RDF through drip, T4- 100% RDF through flood irrigation and T5-absolute control (No fertilizers). Well decomposed FYM compost @ 5 t/ha was applied to all the fertilizer treatments except T5. This experiment was designed in randomised block design and each treatment was replicated four times.

The results showed that application of fertilizer nutrients through drip irrigation system significantly increased plant growth and onion seed yield compared to the plots received 100% RDF through broadcasting under flood irrigation system (T4) and control (T5). Application of 100% (100:50:50:30 kg NPKS/ha) at 6 days interval + 5 t compost /ha (T1) increased seed yield by 35.4% compared to the treatment 100% RDF through broadcasting under flood irrigation system (T4). However, application of 80% RDF at 6 days interval + 5 t compost /ha (T2) produced seed yield at par with 100% RDF at 6 days interval through drip+ 5 t compost/ha. In addition, NPKS uptake and nutrient recovery efficiency was higher in both 100% and 80% RDF applied through drip system. However, the highest cost benefit ratio was recorded in treatments received 80% at 6 days interval + 5 t compost /ha.

7.2.7 Enhancing the yield and quality aspects in banana Var. grand naine through nutrition

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The present investigation was undertaken at Banana Research Station, Nanded, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhaniwith objective to find out the suitable method of application of nutrients and growth regulators for obtaining high yield, quality and better post-harvest quality of banana cv. Grand Naine. The experiment was laid out in Factorial Randomized Block Design having two factors. The factor M consisted two application methods *viz.*M_1- foliar spray and M_2-bunch feeding, Factor B consisted twelve nutrients and plant growth regulators.The results of the field experiment showed that foliar application significantly enhanced the vegetative characters like number of leaves per plant (11.62), leaf length (156.92 cm), leaf breadth (62.60 cm), leaf area (9.59 cm2), leaf area index (3.53) and chlorophyll content in leaves (59.58 spad). Significantly maximum weight of hand, finger weight of first hand, pulp weight, pulp: peel ratio, bunch weight, yield per ha, total soluble solids were recorded in foliar application method. Minimum incidence of sigatoka observed due to foliar application method. However, maximum finger weight of last hand and significantly minimum days to maturity, crop duration was observed in bunch feeding method.With respect to different nutrients and plant growth regulators, application of sulphate of potash (2%) and brassinosteroids (2 ppm) significantly increased yield, quality and post-harvest parameters.Significantly minimum acidity, PLW, rate of respiration and minimum days to maturity was recorded under the application of sulphate of potash (2%) and brassinosteroids (2 ppm).

The treatment combination M_1N_9 (foliar application of sulphate of potash (2%) and brassinosteroids (2 ppm) was recorded significantly maximum weight of hand , finger weight of first hand, pulp weight, peel weight, pulp: peel ratio, bunch weight, average yield, reducing sugar, non-reducing sugar, organoleptic score and chlorophyll content of leaves.

7.2.8 Standardization of stage wise water requirement in sweet orange (*Citrus sinensis* Osbeck)

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The field experiment "Standardization of stage wise water requirement in sweet orange (*Citrus sinensis* Osbeck)" was carried out at All India Coordinated Research Project on Fruits, Department of Horticulture, MPKV, Rahuri in RBD design with five treatments replicated four times with two plants as a plant unit per replication during the year 2011-12 to 2015-16 with an objective to study the water requirement at different stages of growth in sweet orange.

The pooled data of five years (2011-12 to 2015-16) indicated that, the application of irrigation water at different growth stages have significant effect on growth, yield and fruit quality of sweet orange. The treatment T_4 i. e. application of irrigation water at 80:80:80:80:80:0 ER % from stage-I (January-February) to stage-VI (November-December) in sweet orange recorded significantly the maximum plant height (4.73 m), canopy volume (45.97 m^3), fruit weight (194.75 g), number of fruits/tree (335.85), yield (65.33 kg/tree and 18.09 t/ha), juice content (46.18 %), TSS (10.15 ^{o}Brix), ascorbic acid (59.89 mg/100 ml juice), reducing sugars (3.74 %), non- reducing sugars (2.70 %), total sugars (6.36 %) with minimum acidity (0.49 %) and recorded higher benefit: cost ratio (1.55) at the age of 18 years.

The reduction in the irrigation level from 80 ER % to 30 ER % during different stages of fruit growth reduced the yield from 18.09 t/ha to 13.57 t/ha. The treatment T_5 i. e. application of irrigation water at 30:30:30:30:30:0 ER % from stage-I (January-February) to stage-VI (November-December) recorded the highest water use efficiency (1.35 t/ha cm) and obtained normal yield by application of less total quantity of irrigation water (10.01 cm/plant/year) than all other treatments. The total quantity of irrigation water applied from T_1 to T_5 was in the range of 10.01 to 26.11 cm/plant/year through drip irrigation method from stage-I (January-February) to stage-VI (November-December).

The final recommendation is, Irrigation at 80% evaporation through drip for all growing period (January-October) with water stress in November-December is recommended for better growth, yield and quality fruits with efficient utilization of irrigation water in *Ambia bahar* of sweet orange in Western Maharashtra.

7.2.9 Standardization of stage wise water requirement in acid lime (*Citrusaurantifolia* Swingle)

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The field experiment "Standardization of stage wise water requirement in acid lime (*Citrus aurantifolia* Swingle)" was carried out at All India Coordinated Research Project on Fruits, Department of Horticulture, MPKV, Rahuri in RBD design with five treatments replicated four times with four plants as a plant unit per replication during the year 2014-15 to 2018-19 with an objective to study the water requirement at different stages of growth in acid lime.

The pooled data of five years (2014-15 to 2018-19) indicated that, the application of irrigation water at different growth stages have significant effect on growth, yield and fruit quality of acid lime. The treatment T_4 i. e. application of irrigation water at 80:80:80:80:80:80 ER % from stage-I (January-February) to stage-VI (November-December) in acid lime recorded significantly the maximum plant height (3.13 m), canopy volume (23.66 m^3), fruit weight (47.60 g), number of fruits/tree (805.54), yield (38.71 kg/tree and 10.71 t/ha), juice content (49.08 %), acidity (6.85 %), ascorbic acid (32.85 mg/100 ml juice) with minimum number of seeds/fruit (7.80) and rind thickness (1.36 mm) and recorded the higher benefit: cost ratio (1.56) and was at par with the treatment T_3 i. e. application of irrigation water at 60:80:60:80:60:80 ER % from stage-I (January-February) tostage-VI (November-December)at the age of 9 years.

The reduction in irrigation level from 80 ER % to 30 ER % during different stages of fruit growth reduced the yield from 10.71 t/ha to 8.62 t/ha.The treatment T_5 i. e. application of irrigation water at 30:30:30:30:30:30 ER % from stage-I (January-February) to stage-VI (November-December) recorded the highest water use efficiency (0.68 t/ha cm) and obtained normal yield by application of less total quantity of irrigation water (12.51 cm/plant/year) than all other treatments. The total quantity of irrigation water applied from T_1 to T_5 was in the range of 12.51 to 33.36 cm/plant/year through drip irrigation method from stage-I (January-February) to stage-VI (November-December).

The final recommendation is, for acid lime growing under Western Maharashtra**,** irrigation at 60:80:60:80:60:80 ER % during January to December is recommended for better growth, yield, and fruit quality with efficient water use.

7.2.10 Foliar-P fertilization coupled with microbial-inoculants lead to improved potato productivity and quality in Himalayan Acid Alfisol

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Phosphorus nutrition plays an important role in enhancing the productivity and quality of potato crop. However, poor native-P status, low solubility and low P-efficiency ~10-20% across the majority of global arable soils, make P as a critical nutrient that greatly limits plant growth, yield and quality. Majority of the applied-P in acid Alfisols reacts with iron (Fe) and aluminium (Al) ions, thus, forming Fe and Al hydroxyl phosphates that are inaccessible to plants. In order to improve the productivity and P-use efficiency (PUE) in potato crop under Acid Alfisols, devising efficient P-management strategies with integration of soil applied P-fertilizers, biofertilizers and innovative approaches like foliar-P fertilization, may assume utmost importance. AM-fungi and PSB hold great potential in solubilization and mobilization of native and applied-P. Foliar P-fertilization has also shown positive influence on crop productivity and quality in many crops. Thus, foliar-P fertilization along with microbial inoculants like AM-fungi and PSB may prove as a low-cost technology in nutrient exhaustive crops like potato to harness higher yield with higher PUE besides saving soil applied-P. Hence, a field experiment has been conducted for two years during 2021-22 at ICAR-CPRI, Shimla (HP) comprising different P-levels as sole or in combinations with AM-fungi and PSB besides foliar-P fertilization. The results revealed that application of P_{20} + PSB + AMF, P_{20}+2FSP [Twofoliar-P sprays of 2% mono-ammonium phosphate (MAP) applied at vegetative stage (VS) & tuberization stage (TS) in potato]; and P_{20}+PSB+AMF+2 FSP led to 13.4, 12.4 & 18.1% higher tuber productivity over sole use of P_{20}. On an average, application of P_{40} + PSB + AMF, P_{40}+2FSP; and P_{40}+PSB+AMF+2 FSP led to 9.3, 8.1 & 14.4% higher tuber productivity over sole use of P_{40} during two years' experimentation. Sole use of P_{80}& P_{100} had non-significant but 4.8 and 9.1% higher tuber yield over P_{40}+PSB+AMF+2 FSP. It was also revealed that at lower doses of soil applied-P, the response of PSB + AMF or foliar-P was better (11.8–19.2%) over their application at the higher soil applied-P doses (8–15%). The quality parameters like starch, amylase and TSS also got improved under P_{40}+PSB+AMF+2 FSP; avowing the obvious role of foliar-P and microbial-inoculants in influencing potato tuber quality. Hence, integrated P-use through soil applied-P, foliar-P and microbial inoculants like PSB + AMF, can be a low-cost crop management technology under low soil applied-P situations with minimal tuber yield compromise in the acid Alfisols.

7.2.11 Nitrogen and water use efficiency of cocoa varieties as influenced by different levels of nitrogen

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Water use efficiency (WUE) is an essential parameter for assessing the sustainability of agricultural

production systems. It is defined as the amount of biomass or yield produced per unit of water consumed by a plant. Nitrogen is crucial for plant growth and plays a significant role in improving WUE by enhancing photosynthesis. In this context, a hydroponic study was conducted at ICAR-CPCRI, Regional Station, Vittal to investigate the effects of three nitrogen levels (40, 80 and 120 ppm) on dry matter production, nitrogen use efficiency (NUE) and WUE of eight cocoa varieties. Increasing nitrogen concentration led to a significant increase in dry matter production and WUE. Cocoa hybrid VTLCH-1 recorded maximum dry matter (57.87 g) at the highest N level. Nitrogen uptake positively influenced the WUE in cocoa (r=0.55*). The dry weight of fine rootswas positively correlated with nitrogen uptake (r=0.64*) andWUE (r=0.49*). Among different cocoa varieties, VTLCS-1 recorded maximum NUE (0.065 g/mg) followed by VTLCH-1 and VTLCC-1 (0.063 g/mg) at low N level. Similarly, the highest WUE was recorded in VTLCS-1 (2.56 g/L) which was *on par* with VTLCC-1 (2.51 g/L) and VTLCH-1 (2.49 g/L). However, VTLCH-3 recorded minimum NUE (0.051 g/mg) and WUE (2.22 g/L). The findings of the study indicated that, WUE was positively influenced by nitrogen application and N uptake and the varieties VTLCS-1, VTLCH-1 and VTLCC-1 were found to be the most N use efficient which makes them suitable for cultivation in soils with low nitrogen. Identifying the N use efficient varieties is of utmost importance as they can perform better even at the lower N levels there by reducing the N input and making the production system environmentally sustainable.

7.2.12 Modeling spatiotemporal dynamics of Nitrogen and water under different fertilization and land configuration strategies using HYDRUS package

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With the advancement of computational facilities, simulation models have evolved as a very useful tool to improve our understanding of soil-water-plant interactions under a variable set of input strategies. In agricultural fields, nitrate losses are the dominant cause of non-point source pollution. Simulation of nitrogen (N) uptake during crop growing season is very practical in improving fertilizer management and environmental protection. In this study, the HYDRUS-2D model is used which has proven its wide applicability to predict the water flow and fate of nutrients in soil. The model was applied to evaluate the spatiotemporal variations of soil water and nitrate dynamics under different fertilization and land configuration strategies for *rabi*maize in the mid-Indo-Gangetic plains. The main objectives of this study were to simulate N uptake and transport under furrows and ridges during the maize-growing *rabi* season of 2022 and 2023 under different N doses. Maize was planted with differentapplication rates of urea including control (0), Recommended dose (150), Soil Test Crop Response based (180) and Farmer's practice (250kg N ha^{-1}) respectively. Data from the first (2022) and second (2023) seasons were used to calibrate and validate model parameters,respectively. Thesoil water content and nitrate-N and ammonium-N concentrations in different depths at 2, 5, and 10days interval after fertilization application were measured during both seasons. Results indicated appropriate agreement between predicted and measured water content, nitrate and ammonium distribution in soil during the validation stage.The

ranges of the normalized root mean square error (NRMSE) for nitrate and ammoniumconcentrations in soil for all treatments have implied a fair accuracy of the HYDRUS-2D model. Additionally, it could be concludedthat the HYDRUS-2D model, instead of labor- and time-consuming and expensive field investigations,could be reliably used for determining the optimal scenarios for fertilization and irrigation strategies in rabi maize for mid-IGP.

7.2.13 Standardization of suitable varieties and best planting time for commercial cultivation of banana in *Tarai* region of Uttarakhand

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A field trial was conducted during the year 2018 to 2020 at the Horticulture Research Centre(HRC), Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar to standardize the suitable varieties and best planting time for commercial cultivation of banana in *Tarai* region of Uttarakhand. The trial was comprised of three planting time&5 varieties (collected from ICAR-NRC-banana in 2018) and symbolized as S and V, respectively. The interaction effect of three plantingtime (viz. March, May & July)and five banana varieties (namely Grande Naine, Poovan, Ney Poovan, Red Banana & Monthan) on plant growth, yield and quality characteristics were found statistically significant. The significantly higher bunch weight (21.14 kg), yield (52.84 t/ha), finger length (19.00 cm) and B:C ratio (2:1) were registered with the cultivar Grande Naine planted in May month (S_2V_1). The maximum duration from shooting to harvest (193 days) was recorded with March planting in cultivar Poovan (S_1V_2), while,maximum duration from planting to shooting (746 days) was observed with July planting in cultivar Red Banana (S_3V_4). The significantly maximum pseudostem girth (58.10 cm) and maximum hands per bunch (12.75) were recorded with May planting in cultivar Poovan (S_2V_2) however; maximum pseudostem height (3.15 m), finger weight (170.97 g) and pulp weight (120.43 g) were observed with March planting in cultivar Monthan (S_1V_5). Significantly maximum TSS (23.80 ^{0}B) and number of fingers/bunch (162.50) were recorded in cultivar Ney Poovan planted in May month (S_2V_3). The maximum leaf area (16.04 m^2/ plant) was observed in cultivar Red Banana planted in May month (S_2V_4). The maximum shelf life (8.75 days) was recorded in cultivar Monthan planted in May month (S_2V_5), while maximum acidity (0.51%) was found in banana cultivar Ney Poovan planted in March month (S_1V_3).

Thus, on the basis of results, the banana variety Grand Naine (G-9) is recommended for table and Monthan for vegetable purposes with planting during 2nd fortnight of May to 1st fortnight of June for commercial cultivation in *Tarai* region of Uttarakhand.

7.2.14 Water conservation strategy for fruit production

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India has 16% of the world's population and only 4% of the world's water resources, which are degrading rapidly. The demand for water is expected to grow from 40 billion cubic metres (bcm) currently to around 220bcm in 2025. Water is one of the most important inputs essential for fruit crops. Water is an important essential natural land resource affecting growth and production of fruit crops. Fruit trees require irrigation water for maintaining adequate growth, fruit quality and yield, particularly in dry months. However, availability of water is always a limiting factor in fruit cultivation, particularly in arid and semi arid conditions. Even in high rainfall (>1500 mm) areas, sufficient moisture may not be available in the root zone during the dry months and crops may suffer from drought at any stage due to erratic rainfall pattern and for the want of irrigation water. In order to ensure the supply of requisite quantity of water at critical stages of growth and development of fruit crops, efficient management of water is required. In rain fed areas, three essential components of water management are in situ moisture conservation, water harvesting, and efficient utilization of conserved/harvested water through improved cultural practices. Under in situ soil moisture conservation mulching is known to conserve soil moisture, be it mulching with organic or inorganic material. About 10 to 14 per cent of total rainfall, depending on soil and rainfall characteristics may be lost as surface runoff. Water harvesting can be done through in situ rainwater harvesting and water harvesting in farm ponds. In situ rainwater harvesting: In fruit plantations, rain water can be harvested in the tree basin areas by certain soil working techniques such as preparation of tree basinsfor arid and semi-arid regions, soil working techniques like 'Crescent Bund with Open Catchments Pits Trench Systems V-ditch etc. provide satisfactory in-situ harvest of rain water. These techniques are found to be useful for conserving soil moisture in the root zone of trees for the dry months. The water conserved/harvested from natural resources must be used very efficiently for fruit crops. The water should be possibly be used through pressurized irrigation system and deficit irrigation system e.g. drip irrigation system is ideal for fruit crops, because it enable to achieve higher water use efficiency and also help in maximizing crop production within limited water resource. Deficit irrigation (DI) strategies, which involve reducing the amount of water provided to the crop during the growing season by the soil moisture stock, rainfall and irrigation to a level below that needed for maximum plant growth. In most of cases DI induces a gradual water deficit, due depletion of soil water reserves, accompanied by a reduction in harvestable yields, especially in soils with a significantly low water storage capacity.

7.2.15 Standardization of irrigation and fertigation schedule for tomato cultivation under soil less media

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A study on "Standardization of Irrigation and Fertigation schedule for Tomato cultivation under Soil

less Media" was conducted with eighteen treatments. The treatments comprised with different soil less media like Cocopeat, Perlite,Vermiculite,Vermicompost and sand along with three levels of RDF and two levels of irrigation. The tomato plants planted in grow bags irrigation and fertigation applied with drip irrigation system. Tomato crop of variety Avinash-2 was selected for experiment. The field layout done by using CRD with three replications.

The seasonal crop water requirement of tomato plants in soilless media in grow bages cultivation varies from 17.37 to 21.71 cm under irrigation level 80% and 100% Etc. The best growing media was found Cocopeat + Perlite + Vermicompost (3:1:1). The composite effect of growing media, irrigation and fertigation on vegetative growth and yield parameters (fruit length, fruit diameter, numbers of fruit per plant, fruit weight, yield per plant) was found better in treatment M1I2F1 (Cocopeat + Perlite + Vermicompost + 0.80 ETc + 125 % RDF). The maximum average vegetative growth was recorded as 102.12 cm, fruit length 5.55 cm, maximum diameter 5.29 cm, average numbers of fruit per plant 63.73, average fruit weight 90.82 g, and maximum yield 5.23 kg per plant was recorded. However, the minimum yield was (2.88 Kg) under M1F3I2 treatment. The B: C ratio of 3.12 and maximum net income of Rs 211211/- per 1000 m^2 in treatment M1I2F1 and minimum B: C ratio of 1.46 in treatment M1F3I2 (control).

TECHNICAL SESSION-8

PRECISION SYSTEM FOR PLANT HEALTH MANAGEMENT OF HORTICULTURAL CROPS

8.1 Kenote Lectures

8.1.1 Bio-intensive pest management approaches for recently invaded invasive insect pests of horticultural crops in India

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Invasions of alien insect pests cause a greater negative impact on the native ecosystem and biodiversity. Increased global trade in agriculture and horticulture has increased the chances of the introduction of alien pests. India witnessed its first invasive pest San Jose scale, *Comstockaspis perniciosa* (Comstock) in 1879 from China and has recorded a total of 32 species thereafter. Of these, 20 species belong to the order Hemiptera, 4 species belong to Lepidoptera, 3 are from Coleoptera, 2 each from Diptera, Hymenoptera and Thysanoptera. Horticultural crops are the preferred hosts for the majority of the invasive pests invaded in India. The losses caused by these invasive pests are immense as natural enemies of these pests invariably will not be readily available to manage them. Recent invasives in horticultural crops include, Papaya mealybug *Paracoccus marginatus*Williams and Granara de Willink; Banana mealybug *Pseudococcus elisae* Borchsenius; Litchi longhorn Beetle/ Guava stem borer *Aristobia reticulator* (Fabricius, 1781); Lotus lily midge *Stenochironomus nelumbus* Tok et Kur; Jack Beardsley mealybug *Pseudococcus jackbeardsleyi* Gimpel and Miller; Madeira mealybug *Phenacoccus madeirensis*

Green; Tomato pinworm *Phthorimaea absoluta* Meyrick; Coconut Spindle infesting leaf beetle *Wallacea* sp.; Western flower thrips *Frankliniella occidentalis* (Pergande); Solanum whitefly *Aleurothrixus trachoides* (Back); Legume feeding whitefly *Tetraleurodes acaciae* (Quaintance); Rugose spiralling whitefly *Aleurodicus rugioperculatus* Martin; Fall Armyworm *Spodoptera frugiperda* (J. E. Smith);Bondar's nesting whitefly *Paraleyrodes bondari* Peracchi; Nesting whitefly *Paraleyrodes minei* Iaccarino; Neotropical palm infesting whitefly *Aleurotrachelus atratus* Hempel; Woolly whitefly *Aleurothrixus floccosus* (Maskell) and South Asian Thrips, *Thrips parvispinus* (Karny). All these invasive insect pests recently caused considerable yield loss in the horticultural crops. Invasive species also threats to agricultural biodiversity as well as human and animal health. Though many organizations were involved to curb such invasions, strict implementation of import regulations and international cooperation in trade and commerce, early detection, and taxonomic identification at the entry point's wold make India safe and secure from such invasive species. The impact of invasion of insect pests can be minimized with international cooperation through exchange of information on invasive pests and their natural enemies. The present paper critically reviews the recent invasive insect pest problems in the horticultural crops, management of these invasives using biointensive approaches, existing plant quarantine regulations in India, and way forward to safeguard Indian Agriculture.

8.1.2 Production of clean planting materials of citrus with special reference to budwood certification programme

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Certification programme with the objective of producing certified elite quality nursery plants can prevent or eliminate graft transmissible systemic and destructive pathogens before they enter the mainstream of budwood supply of the region.Any country contemplating to establish a healthy citrus industry has to implement a certification scheme. This will ensure that all budwood available in a country is certified free from such major graft transmissible diseases. In India, mostly citrus trees are propagated with budwood of uncertain origin in thousands of small nurseries that includes private as well as government nurseries. The use of such budwood from infected trees in the nursery for propagation is the primary cause for the distribution of the diseases. Efforts were made in the past few decades to implement budwood certification program. However, very little progress was made mainly because of lack of suitable infrastructure facilities for virus detection, unavailability of proper well trained scientific personnel, poor co-ordination between government department, research institutes and nursery owners and more importantly the lack of awareness among farmers. Internationally accepted molecular and bio-diagnostic techniques of virus indexing of mother plants of citrus has been standardized at ICAR-CCRI, Nagpur to develop virus-free planting material of Nagpur mandarin, Mosambi sweet orange, acid lime etc for the citrus growers of the country. Certification program, an essential step in producing high quality citrus trees has to be established in all citrus growing belts of the country in a national network mode for better citrus industry of the country. Central Citrus Research Institute, Nagpur has taken up the budwood certification program and systematic efforts have been made to achieve an annual production target of about six lakh disease-free quality planting materials. The impact of investments in horticultural research can be realized only if farmers have better access to high-quality disease-free planting materials

of the improved varieties at reasonable costs and at their production sites. Though network of ICAR institutes and State Agriculture Universities (SAUs) on planting material production has intensified the work on production of quality planting material of different plants, however, more need to be done for upgrading testing facilities for viruses and pathogens and also for indexing and mapping of viruses. The concept of Clean Plant Program (CPP) is unique in itself and would go a long way in catering the availability of clean and quality planting materials throughout the country.

8.1.3 Citrus budwood certification program and production of disease-free quality planting material: A success story

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Citrus is the third most important fruit crop in India, after banana and mango, with an estimated production of 14 million tonnes of fruits and area coverage of 10.5 lakh hectares (Horticultural Statistics at a Glance, 2021). The important commercial citrus fruits in India are mandarins (*Citrus reticulata* Blanco), sweet orange (*C. sinensis* Osbeck) and acid lime (*C. aurantifolia* Swingle). Incidence of various diseases are the bottlenecks accounting for overall low average productivity (last few decades) of 8-10 tonnes/ha which is far below the average productivity of 25-30 tonnes / ha attained in the frontline citrus growing countries like Brazil, USA, Spain. Heavy infestation of graft-transmissible pathogens (which are inadvertently spread through vegetative propagation) is one of the major factors for the poor yield, short productive life and gradual decline of citrus trees. These graft transmissible pathogens include several viruses, viroids, systemic prokaryotes such as bacterium causing Huanglongbing (citrus greening) and phytoplasmas. Only preventive measures such as use of tolerant or resistant germplasm and planting pathogen-free, high quality nursery trees are useful for the control of these pathogens. This is the compelling reason for adoption of certification program for citrus, to exclude graft-transmissible pathogens from new orchard establishment as well as re-plantation. ICAR-Central Citrus Research Institute (CCRI), Nagpur has taken a committed campaign to implement citrus budwood certification programme for producing certified quality planting material of Nagpur mandarin, acid lime and Mosambi sweet orange by adopting the most contemporary and internationally accepted techniques standardized at the centre. About three lakhs disease-free plants are being developed by the institute since last about twenty years to supply to government nurseries for raising mother blocks and to the citrus growers as well. The impact of investments in horticultural research can be realized only if farmers have better access to high-quality disease-free planting materials of the improved varieties at reasonable costs and at their production sites. Though network of ICAR institutes and State Agriculture Universities (SAUs) on planting material production has intensified the work on production of quality planting material of different plants, however, more need to be done for upgrading testing facilities for viruses and pathogens and also for indexing and mapping of viruses. The concept of Clean Plant Program (CPP) is unique in itself and would go a long way in catering the availability of clean and quality planting materials throughout the country.

8.1.4 Consumer awareness and product incentives may accelerate the IPM adoption among the horticulture farmers

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In western countries, consumers are becoming increasingly interested in how their food is grown and what impacts the food production systems are making on the environment. News reports and stories about the health and safety of our food production and supply chain are published (Web reference). As per the Government of India portal, IPM packages have been developed for 87 crops as well as 14 crop-specific POP have also been recommended. Institutions promoting alternative pest management practices in Indian Agriculture are 37 Central Integrated Pest Management Centres (CIPMC) in different states, 730 KVKs in different states, almost all Agricultural universities of India, various NGOs, organic farming centers, other institutions, Agriculture and Horticulture department of different States including ICAR institutes. Keeping corporate farming aside, various studies indicate that farmers in India still prefer chemical control, mostly getting their plant protection advice from dealers, and some from extension officials. The majority of the farmers initiate the plant protection action based on the first appearance of the pest in high-value crops and therefore, the cost of plant protection on various crops becomes a lion's share of crop production cost. Therefore, it remains vital to assess and work out to what extent the alternative tools and recommended IPM practices are adopted by Indian farmers.

To cater to the farmers' needs, there are nearly 361 bio-control laboratories in India (CIPMCs - 35, ICAR/SAUs/ DBT - 49, State bio-control labs -98, private sector labs 14, and State biocontrol labs covered under Grants-in-Aid of Government of India- 38). To reduce the consumption of conventional pesticides, the Government of India has published a gazette notification to ban around 27 pesticides recently. The proposed banned pesticides list has a lion's share (around 55%) in Indian agriculture as per years back data of Directorate of Plant Protection Quarantine & Storage (DPPQ&S).

IPM was supposed to ensure pesticide reduction in agriculture and the same is seen in pesticide consumption data provided by DPPQ&S. However, there remains a doubt if this reduction in pesticide consumption is due to the adoption of IPM or due to the introduction of the more toxic molecule and their recommended low dose per hectare; nearly one third or half of the conventional pesticide dose.

Insecticides give instant and visual results and the problems, associated with them are not sufficient to change farmers' attitudes. Farmers emphasize their economic concerns more than other social/health or environmental concern. Poor availability of IPM components, weak or superficial results of alternative IPM tools at farmers' fields due to half hearted demonstrative efforts, poor or no enforcement from consumers for non-chemical products, and no additional incentive against chemical farming maybe some of the reasons for it.

There is a lack of organized markets or incentives for IPM products as seen in the case of organic products. It is well known that market access by IPM farmers and consumer preference for IPM-produced commodities affect the demand for IPM packages by growers (Buckmaster et al., 2014).

Good Agricultural Practices (GAP) -IPM products generally don't have a separate domestic market as in the case of organic products and therefore, these are sold out in the market side by side with chemically grown produce almost at the same rate. Though these GAP-IPM farmers make extra efforts to produce safe food in the larger interest of the society and environment, they don't get added monetary benefit in the market. Therefore, the economic, as well as protection outcome by alternatives pest management tools are not much appreciated by the farmers and at the same time, alternative plant protection tools remain within reach of a few farmers despite massive efforts by the public sector.

Though alternative crop protection measures have tremendously improved in the last 50 years and will continue to do so, yet it is presumed that natural products/ alternative methods of plant protection will not per se play a dominant role soon unless low input agriculture (GAP-IPM) is incentivized by creating new production and consumer awareness and marketing system thereof. Till then, chemical molecules such as pesticides will remain the most important source of plant protection.

India has only two segments of food supply in its chain. It is either organic at a higher rate than that of chemically grown or chemically grown at the prevailing market rate. In most cases, food grown using IPM practices is not identified in the market place like *organic* food. There is no national certification for growers using IPM. Since IPM is a complex pest control process, not merely a series of practices, it is impossible to use one IPM definition for all foods and all areas of the country. In some countries, many individual commodity growers, for such crops as potatoes and strawberries, are working to define what IPM means for their crop and region, and IPM-labeled foods are available in limited areas. With definitions, growers could begin to market more of their products as *IPM-Grown*, giving consumers another choice in their food purchases. Study of consumer response to fresh produce grown with integrated pest management (IPM) techniques and determine the market potential for IPM labeled products in the northeastern United States, the studies indicated thatless than 12 percent of consumers know what IPM is. Whereas, according to a study conducted by Govindasamy and John Italia(1997), about 31percent of respondents had prior knowledge about IPM. There is a lot of variation in the awareness of environmentally friendly products among different segments of the population. They have conducted several studies on consumers' awareness and preference for IPM produce (Govindasamy *et. al.,* 1998,1999, 2003) however, in India such IPM certification programmes and studies on consumer awareness of IPM produce are lacking.

India has nearly one percent households of rich (3 millon households with a 16 million population) having an income of above INR 17 lakh. This group is aware of food safety and quality and therefore can choose and afford safe food such as organic produce. A middle class of 13 percent (31millon households with a 16 million population) has an income of INR 3.4 -17 lakh. They may be aware of food safety and quality but only three to five percent can afford organic produce while five to eight percent can afford GAP-IPM produce which costs less than organic produce but a bit more than chemical produce. There is an aspiring group (30 %) of 71 million households with 359 million population having income INR 1.5 -3.4 lakh. This group spends more on protein and fat but is not much concerned about food safety and quality however, one to two percent of them can afford (GAP-IPM) low input produce. There is a big section of deprived (56 percent) class of 135 million households with 684 million populations having an income of below INR 1.5 Lakh. For this class, food is a priority, not food safety or quality. As such, there is a segment of nearly 13-15 percent population that can afford to support GAP-IPM farmers by spending a bit more on safe food, but where are the shop and vendors?

At this juncture there is a question "can we create a third segment of the food supply chain with a field to fork system" for GAP-IPM produce for 13-15 percent Indian population who are ready to pay for it, if they get an option in the market to choose and purchase it.

This will incentivize the GAP-IPM and consequently, faster adoption of safe plant protection measures and gradual reduction in dependence on pesticides.

8.2 Oral Presentation

8.2.1 Population dynamics of *Aphis Gossypii* (Glover) and Cucumber mosaic virus incidence in Banana in the Raver region of Maharashtra.

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India leads the world in banana production with an annual output of about 29.8 million metric tons, contributing to 27% of the world's banana production. Banana plants like other crops are affected by biotic and abiotic stresses. Four viruses viz. Cucumber mosaic virus (CMV), Banana bunchy top virus (BBTV), Banana streak virus (BSV) and Banana bract mosaic virus (BBrMV) are responsible for substantial economic losses. In Jalgaon, CMV was first observed in 1943. CMV has become the most concerning virus in Maharashtra; its incidence has been more frequent since the past six years. The CMV infection is transmitted by Aphid vector in banana plants in a non-persistent manner. The aim of this research work is to study the source of inoculum and vectors, and population dynamics of vector in relation to CMV incidence in banana in the raver region of Jalgaon Maharashtra. Study was carried out in banana plantations from July 2020 to Oct 2022. It was found that the *A. gossypii* population began to increase exponentially from the second week of July 2020, attained its peak in the middle of August 2020 and started decreasing from the second week of September 2020. CMV infection on Banana plants was observed 70 percent during this period (July to Sep 2020). In 2021, *A. gossypii* population did not increase multifold in July to September months and CMV infection was found to be less (1-2%). Similar observations were also recorded in 2022 as compared to 2020. Among the 29 common weeds from the region 16 weed species were found positive for CMV. Solanaceae and Portulacaceae family's CMV positive weeds were found to cover more land inside and on boundaries of banana fields under study. It is concluded that increase in *A. gossypii* population is directly correlated with the CMV infection on banana plants. CMV positive weeds present near banana orchards serve as a potential inoculum source of CMV that is carried by aphids to banana plants.

8.2.2 Production potential and economics of integrated weed control measures in ginger

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A field experiment was carried out during 2014 and 2015 to evaluate the effect of integrated weed management on growth, yield, weed control efficiency and economics of ginger. The experiment was laid out in a randomized block design with nine integrated weed management treatments viz T_1: Pendimethalin @ 1.5 kg/ha (after planting but before mulching); T_2: Oxyfluorfen @ 0.20 kg/ha (after

planting but before mulching); T_3: Pendimethalin @ 1.5 kg/ha fb hand weeding (after planting but before mulching fb 30-35 DAP); T_4: Oxyfluorfen @ 0.20 kg/ha fb hand weeding (after planting but before mulching fb 30-35 DA; T_5: Glyphosate @ 0.80 kg/ha (just before emergence of sprouts of ginger); T_6: Glyphosate @ 0.80 kg/ha + Pendimethalin @ 1.5 kg/ha (just before emergence of sprouts of ginger); T_7: Glyphosate @ 0.80 kg/ha + Oxyfluorfen @ 0.20 kg/ha (just before emergence of sprouts of ginger); T_8: Hand Weeding (twice at 30 and 60 DAP); T_9: Unweeded control and three replications. The results revealed that hand weeding twice at 30 and 60 DAP (T_9) recorded lowest weed population (6.20, 7.38/m^2), dryweight of weeds (11.80, 10.23 g/m^2) and highest weed control efficiency (WCE) (84.97%, 86.62%) which was followed by application of glyphoste @ 0.80 kg/ha + pendimethalin @ 1.5 kg/ha (T_6) and glyphoste @ 0.80 kg/ha + oxyfluorfen @ 0.2 kg/ha (T_7) before emergence of sprouts of ginger in both the years. However, T_6 and T_7 significantly improved the rhizome yield to the tune of 86.9, 81.5 and 91.8, 93.9 % over the control during the years respectively. Highest Gross returns ((^{1}†/ha 213200), Net returns (^{1}†/ha 110400) and B:C ratio (2.07) was obtained with T_7 followed by T_9. Hence, it may be concluded that for better ginger productivity and weed management with two hand weeding at 30 and 60 DAP; or application of glyphoste @ 0.80 kg/ha + oxyfluorfen @ 0.2 kg/ha is the most potential and viable practices under rainfed ecosystem of Bihar.

8.2.3 Identification of potential chemo-types of *Bacopa monnieri* L. Pennell for herbage yield and nootropic parameters

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Bacopa monnieri is a well-known Indian medicinal plant as Jal Brahmi has been used as a memory enhancer in Ayurvedic as well as other medicinal system. The brain tonic property is mainly because of presence of saponins, especially Bacosides. Brahmi has antipyretic, anti-inflammatory, analgesic, sedative, free radical scavenging and anti-lipid peroxidative activities. Moisture content of Brahmi was 88.78% moisture while leaves contain lesser amounts of protein and fat. It also contains significant amount of ash of 1.94%. This indicated that the presence of more minerals in the leaves such as sodium, potassium, iron, calcium, phosphorus and chlorine.

Jal brahmi accessions were evaluated on the basis of their important morphological characters, herbage yield and chemical constituents. Morphological parameters show significant variation for leaf size, leaf shape, flower colour, stem colour, pedicle length, herbage yield and yield contributing parameters. Accession, INGR21237 showed maximum fresh and dry herbage yield as well as maximum fresh and dry root yield under pot experiments. However, maximum total bacoside as well as bacopaside I was reported in INGR21236. Leaf samples observed rich in (bacopaside I, bacopaside II, Bacoside A, bacoside A3 and total bacoside) as compared to stolon sample in all accessions. The elite DBM-4 suitably cultivated under 75% SNI for getting maximum secondary metabolites yield for efficient industrial use. The INGR21237, an accession of Jal brahmi was found the most promising accession providing the maximum yield of fresh and dry herbage as well as fresh and dry root. The accession INGR21236 is also suitable for product development or pharmaceutical industries due to rich quality parameters *viz*., total chlorophyll, carotenoids, bacosides A content, low in drying/ash, and high in water and alcohol extractive.

The accession INGR21236 was found suitable for commercial cultivation in low-lying rice-wheat cultivation systems and farmers can get approximately Rs. 4.62 lakhs ha-1 year-1 net return. Therefore, Jal Brahmi (INGR21236) has all potential to establish itself as a sustainable substitute for Rice-wheat crop cultivation. At the same time, this crop could also be cultivated under partial shade conditions.

8.2.4 Unfolding the mitochondrial genome structure of green semilooper (*Chrysodeixis acuta* Walker): An emerging pest of onion (*Allium cepa* L.)

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Onion is the most important crop challenged by a diverse group of insect pests in the agricultural ecosystem. The green semilooper (*Chrysodeixis acuta* Walker), a widespread tomato and soybean pest, has lately been described as an emergent onion crop pest in India. *C. acuta* whole mitochondrial genome was sequenced in this work. The circular genome of *C. acuta* measured 15,743 base pairs (bp) in length. Thirteen protein-coding genes (PCGs), 22 *tRNA* genes, two *rRNA* genes, and one control region were found in the 37 sequence elements. With an average 395 bp gene length, the maximum and minimum gene length observed was 1749 bp and 63 bp of *nad5* and *trnR*, respectively. Nine of the thirteen PCGs have (ATN) as a stop codon, while the other four have a single (T) as a stop codon. Except for *trnS1*, all of the *tRNAs* were capable of producing a conventional clover leaf structure. Conserved *ATAGA motif* sequences and *poly-T* stretch were identified at the start of the control region. Six overlapping areas and 18 intergenic spacer regions were found, with sizes ranged from 1 to 20 bp and 1 to 111 bp correspondingly. Phylogenetically, *C. acuta* belongs to the *Plusiinae* subfamily of the *Noctuidae* superfamily, and is closely linked to *Trichoplusia ni* species from the same subfamily. In the present study, the emerging onion pest *C. acuta* has its complete mitochondrial genome sequenced for the first time.

8.2.5 Fungal and Bacterial Biopesticides based Management of *Scirtothrips dorsalis* and Invasive *Thrips parvispinus* in Bell Pepper and Chillies

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Sucking pests is major problem in vegetables crops especially Thrips species is very challenging to the vegetable growers in India. One of the important vegetable bell pepper under protected and open field

conditions dramatically affected by *Scirtothrips dorsalis* eventually leads to huge crop loss to the farmers. This *S. dorsalis* affect the quality and yield of bell pepper results in reduction of export of this vegetable to other countries. ICAR-NBAIR carried out continuous research for the management of this thrips species under lab and field conditions. Results under protected cultivation and open field conditions showed impressive reduction of *S. dorsalis* population and increased yield of bell pepper. Plant growth promoting rhizobacteria *Pseudomonas flourescens* NBAIR-PFDWD and *Bacillus albus* NBAIR-BATP either individually and in consortia formulation effectively decrease the *S. dorsalis* population and increased the yield of the bell pepper crop with effective growth hormone production like Indole acetic acid (IAA). Recently, sudden outbreak of invasive *Thrips parvispinus* leads in the severe infestation of chilli crop in Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra, Haryana and Chhattisgarh. ICAR-NBAIR screening several entomopathogenic fungus from microbial repository showed excellent control of *T. parvispinus* under lab and field conditions at different locations. *Beauveria bassiana* NBAIR-Bb5a and *Lecanicillium fusisporum* NBAIR-VL8 are very important entomopathogenic fungi in the management of this invasive *T. parvispinus*. Under different field locations these entomopathogenic fungi and bacteria effectively controlled *T. parvispinus* in chilli crop and increased the yield of chilli.

8.2.6 Effect of climatic factors on whitefly incidence, disease transmissibility and potato yield loss due to ToLCNDV in North-Western India

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Potato is grown in almost all the states under diverse climatic conditions. Climatically, there is a short window in which potato has been fitted with appreciable use realized even 80 to 90 days old crop. More over a few other crops produce comparatively high yields of nutrients per unit area where land is scare. That's why potatoes highly important for many small and marginal families of the country. Among the various factors related to insect pest and diseases, potato farmers are increasingly forced to face water stress change, changes in rainfall patterns and its intensity, frost and fog etc. These conditions are generally interpreted to climate changes. Potato production is highly dependent on climate and weather factors. Pests such as whitefly, aphids, thrips, hoppers and mite may become more serious in last few decades on potato crop because they are not only suck the sap from tender parts but also transfer number of viral diseases, resulting quick degeneration of potato. The correlation studies (r) between weather parameters and *B. tabaci*population on potato revealed thatthe maximum temperature exhibited non-significant negative relationship (r= -0.10) but, minimum temperature showed non-significant positive relationship (r= 0.17) respectively, while maximum relative humidity showed significant negative relationship (r= -0.24) and however, minimum relative humidity have showed non-significant negative relationship (r = - 0.05) with*B. tabaci*population, where as rainfall exhibited significant negative relationship (r= - 0.25) with *B. tabaci*on potato during crop seasons from October, 2008 to December, 2018. High incidence of apical leaf curl disease was recorded in Kufri Anand, K. Badshsah, K. Pukhraj and K. Sutlej with ToLCNDV-potato when crop was grown from infected seed of ToLCNDV-potato. However, K. Bahar showed slow and steady development of ToLCNDV-potato.There is an urgent need to critically and scientifically assess the impact of climate change especially on the sucking insects of potato. The best economic strategy for Indian farmers is to use IPM practices, monitor insect pest occurrence and further buildup on potato crop.

8.2.7 Need of sertification standards for clean grapevine planting material in India

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Grape (*Vitis vinifera*) is one of the important fruit crops in India. Currently it is grown on an area of about 0.16 million ha with production of about 3.48 million tons. Use of clean, disease-free planting material is paramount for maintaining high productivity, fruit quality and value-added products. Grape planting material in India, is in high demand for establishing new vineyards as well as replacement of vines in old vineyards. This demand is met by private nurseries or grape growers who utilize conventional methods such as cutting, budding and grafting without much focus on disease-freedom. Grapevines are adversely affected by several biotic factors including fungal, viral and bacterial pathogens, insects and nematodes. Grapevines are infected by about 86 different viruses, which can severely affect fruit yield and vineyard productivity. About 9 viruses and viroids infecting grapevines have been reported from India. Currently no chemical methods are available to eliminate viruses from infected plants and these viruses are primarily spread through infected planting material. We, therefore, propose the development of a three-stage system to ensure production of disease-free clean planting material of grapevine scions and rootstocks. This system consists of production of nucleus stock, foundation stock and certified stock as per Indian Minimum Seed Certification Standards 1966 and National Certification System for Tissue Culture Raised Plants (NCS-TCP), 2006. The nucleus stocks will be developed by the ICAR-NRCG, Pune after testing commercial cultivars/rootstocks for diseases and pests including viruses and viroids followed by micropropagation, which includes meristem tip culture and chemo-/thermo-therapy for the elimination of viruses/viroids, if any. The nucleus stocks of zone-specific cultivars and rootstocks will be further propagated through conventional methods by horticultural institutes located in north, central and south India under strict sanitary conditions and routine testing for disease-freedom including viruses for producing foundation stocks. Foundation stocks, thus, produced shall be distributed to the voluntarily registered nurseries and grape growers for developing mother blocks and production of certified planting material. Inspections in different production stages shall be carried out by the seed certification agencies of respective states. The successful implementation of this system will enable Indian growers to maintain healthy vineyards while also helping them to achieve higher grape productivity.

8.2.8 Host, virus and vector interactions in CMV disease of banana in Maharashtra

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In order to understand the host, virus vector interactions in banana plants were studied under field conditions in Jamner taluk of Jalgaon district of Maharashtra. The viral infection was transmitted by the CMV vector, *Aphis gossypii*. The aphid acquires viral infection from weed host and transmit the

disease to banana plants. The aphid colonises more on the weed plants rather than on banana plants. The virus acquired aphids move to the banana plants and by probing the virus is transmitted. The disease mapping was carried out at three CMV infected banana gardens at Hiver Kheda and observations relating to number of plants infected in a representative sample area was recorded. The CMV infection was recorded to the tune of 1.77,15.0 and 50.1% respectively in the G-1, G-11 and G-III gardens respectively .50% of the plants indicated plant height reduction in the CMV infected plants. The viral infection manifests various symptoms to the banana plants depending upon the viral titre and the type of viral particles. The necrotic type of infection, stunted growth, mosaic symptom, shoe string, streak, plant mortality types were recorded in the banana gardens. The CMV infection was more in the gardens where the garden is surrounded by weed plants and if there are no r little weeds, the CMV infection was very less. If, the weed hosts are not predominant in and around the garden the CMV infection was very much reduced. The data on the yellow sticky trap also indicated the vector population levels in relation to CMV incidence. The studies have clearly indicated the necessity of weed control in the CMV disease management.

8.2.9 Evaluation of different botanical formulations for management of sucking pests in mango (*Mangifera indica* Linn.)

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The field experiment was conducted to evaluate the efficacy of different botanical formulations for the management of sucking pest in mango (*Mangifera indica*L.) at All India Coordinated Research Project on Fruits, Department of Horticulture, MPKV, Rahuri (MS) during 2020-21 to 2022-23.The trial was conducted in Randomised Block Design with seven treatments *viz*.,Azadirachtin 10,000 ppm (3 ml/l), Botanical formulation “AAVYA” (4 g/l), Neem soap (IIHR product) at 10g/l, Pongamia soap (IIHR product) at 10g/l, alternate spray of Azadirachtin 10,000 ppm (3 ml/l) *fb* Neem soap (IIHR product) at 10g/l *fb* Pongamia soap (IIHR product) at 10g/l and standard check treatment *i.e*., Imidacloprid 17.8 % SL @ 0.3 ml/l *fb* Lambda cyhalothrin 5 EC @ 0.5 ml/lit *fb* Thiamethoxam 25 WG @ 0.3 g/l of water and untreated controlwith four replications were evaluated. Mango trees were selected at the time of panicle initiation and sprays were given as per treatment details.

The pooled data indicated that among different botanical formulations for management of sucking pest in mango, the treatment with alternate spray of different botanical formulations *ie*., Azadirachtin 10,000 ppm @3 ml/l *fb* Pongamia soap @ 10g/l *fb* Neem soap @ 10g/l showed least incidence of mango hopper (2.59 hoppers/panicle) which was at par with Neem soap (IIHR product) at 10g/l (2.67 hoppers/panicle). However, the chemical based treatments Imidacloprid 17.8 SL@0.3 ml/l *fb* Lambda cyhalothrin 5 EC @0.5 ml/l *fb* Thiamethoxam 25 WG @ 0.3 g/l was found significantly superior over other treatments including untreated control for management of mango hoppers (1.22 hoppers/panicle)and thrips (1.99 thrips/panicle) on mango. Among the botanical formulations, the treatment with Neem soap at 10g/l and alternate spray of different botanical formulations *i.e.,* Azadirachtin 10,000 ppm @ 3 ml/l *fb* Pongamia soap @ 10g/l *fb* Neem soap @ 10g/l were equally effective against thrips with 3.43 and 3.45 thrips/panicle, respectively. Among the botanicals the maximum fruit yield was obtained in the treatment with Azadirachtin 10,000 ppm *fb* Pongamia soap *fb* Neem soap (32.78 kg/tree) which was at par with Neem soap (31.53 kg/tree) alone.

8.2.10 Management of stem-end rot of sweet orange caused by *Colletotrichum gloeosporioides*

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Field trials were undertaken for four consecutive crop seasons (2018-19to 2021-22) to test the efficacy of new molecules of fungicides and bioagents against stem-end rot of sweet orange at All India Coordinated Research Project on Fruits,Mahatma Phule Agriculture University, Rahuri (MS). The experiment was laid out in Randomized Block design with three replications and nine treatments *viz.,* T_1-Carbendazim + Mancozeb 75%WP @2.5 g/lit, T_2-Difenoconazole 25%WP@0.5 ml/lit, T_3-Chlorothalonil 75%WP @2 g/lit, T_4-Tebuconazole 25%EC @0.5 ml/lit, T_5-Thiophanate Methyl 70%WP @0.7 g/lit, T_6-Bordeaux mixture @1%, T_7-*Trichoderma viride* @5 g/lit, T_8-*Pseudomonas fluorescence* @5 g/lit and T_9-Unsprayed control. Foliar applications were applied thrice during the month of July to September at monthly intervals.Sweet orange (*Citrus sinensis* L. Osbeck) is one of the major fruit crop in the State of Maharashtra occupying a unique position. It is third largest crop industry after mango and banana. Sweet orange is known to be affected by several fungal diseases. Recently, the preharvest fruit drop caused by *Colletotrichum gloeosporioides* has become severe which affects the marketable fruit yields. Three sprays at the monthly interval were undertaken from July to September and results revealed that after application of third spray,the fungicide Thiophanate Methyl 70% WP @ 0.7g/litwas found to be significantly superior over control and recorded minimum per cent fruit drop of 4.33%with highest per cent disease control of 53.73 per cent and maximum fruit yield of 45.44 kg/plant and B:C ratio 1: 2.30.

8.2.11 Effectiveness of nylon net against rhinoceros beetle management in coconut (*Cocos nucifera*) palms

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Rhinoceros beetle, *Oryctes rhinoceros* (L.) is a major pest of coconut in India and other coconut producing countries causing direct and indirect losses to the palms. Beetle infestation results in reduced yield and fatal to seedlings, young or old palms in some situations. Adult stage of the beetle causes damage. It makes burrows and resides between leaf sheaths, near the crown and cuts the leaf in unopened conditions. In spite of its successful control, lack of awareness in farmers about the management of rhinoceros beetle is proving to be a setback. In this context, an evaluation trial on effectiveness of nylon net against rhinoceros beetle management in coconut palms under coastal region of Maharashtra (India) was initiated during April 2022 at ICAR-All India Coordinated Research Project on Palms, Regional Coconut Research Station, Bhatye (DBSKKV, Dapoli), Maharashtra, (India). The trial is non-replicated and two to six years old 35 palms were selected for study. The pre-count observations on leaf and spindle damage of palms by rhinoceros beetle were recorded. Post treatment observations were recorded on leaf, spindle damage and number of adults beetle trapped on nylon net

at monthly interval. Results indicated that the maximum leaf and spindle damage were found 28.5 and 17.1 per cent, respectively during pre-count observations in the months of April, 2022. However, minimum leaf damage (26.2%), spindle damage (15%) and adults beetle trapped on nylon net (0.42 nos.) were observed after one months of treatment imposed. In June, 2022, minimum leaf, spindle damage and adults trapped on nylon net were observed 20.9, 14.3 per cent and 0.97 nos., respectively. The decline trends were observed from May, 2022 to December, 2022. In December, 2022, minimum leaf, spindle damage and adults trapped on nylon net were noticed 11.9, 7.99 per cent and 0.65 nos., respectively. Thus, the results revealed that nylon net has effective against the management of rhinoceros beetles in coconut palms and would help to reduce the further crop damage due to rhinoceros beetle in the region.

8.2.12 Masstrappingof fruit fly (*Bactrocera* spp.) – A low cost and Eco-friendly phenology based management strategy in sapota

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Sapota is an important sweet fruit of the tropical region and shown diverse intensification in the recent past. Under the monoculture of Kalipatti variety, fruit fly, *Bactrocera* spp. (Diptera: Tephritidae) is a major pest from consumption and export point of fruit quality globally. Different fruit fly species exist in same host and causes enormous losses in horticultural crops. Therefore, eco-friendly and economical management of fruit fly is very decisive at right time to avoid subsequent pest spread.

The adult fruit fly monitoring trial was carried out in sapota (cv. Kalipatti) orchard of Fruit Research Station, NAU, Gandeviduring four consecutive years. For trapping purpose, one ha sapota orchard area was selected and ten methyl eugenol based modified 'Nauroji Stonehouse traps' (plywood block) developed under Navsari Agricultural University were installed and kept throughout the year at 4-5 feet height from ground level on sapota tree. The plywood blocks were changed regularly when adult catches reach zero. The count of trapped adult fruit flies were taken at standard meteorological week basis and average count of ten traps was calculated for further analyzed of linear correlation and regression equation.

Bactocera dorsalis was the leading species over *B. correcta* and *B. zonata* in sapota. The adult fruit fly activity observed low at middle phase of fruiting in January to February and inclined higher from March onwards. Soon after, population hit the highest point during April to June with the ending fruiting period, which was coincide with the mango fruiting stage under South Gujarat agro-ecological situation. The linear correlation study revealed that the maximum-minimum temperature along with evaporation had positive role in the increasing population build up of fruit fly with lesser morning relative humidity during summer period. The regression equation data specify significant multipart consequences of minimum temperature, morning-evening relative humidity, bright sunshine hours and evaporation. The trapped catches findings indicated that the mass trapping campaign can be initiated February onwards to bring down the male adult fruit fly population below decisive level and to escape damage in advance fruiting phase of sapota.

8.2.13 Status of Cucumber Mosaic Virus (CMV) on banana crop in major growing districts of Maharashtra

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Among the different viruses infecting banana, Cucumber Mosaic Virus (CMV) is causing economic losses in Jalgaon district since last two years. It is a deadly plant virus that results in crop yield losses with serious economic consequences. Considering the importance of disease, the survey work was carried out in the year 2022-23 of different banana growing areas of Maharashtra particularly; Jalgaon, Dhule, Nandurbar, Solapur, Nanded and Ahmednagar districts to study its status and severity. The incidence of CMV was observed in all the districts surveyed with varying range which varied from 5 to 100 per cent. The highest incidence was observed in the Jalgaon district especially in Raver and Muktainagar Tahasils and it was up to 100 percent. The banana crops that were infected had stunted growth with narrower and smaller leaves than usual. Such plants do not produce fruits, but serve as a virus reservoir.

Further, the difference in the incidence of CMV due to planting time was also observed. The incidence of CMV was observed to be very high in July and August plantation in Raver and Muktainagar tahasils of Jalgaon districtand such infection was widespread. However, the negligible incidence of CMV (0 to 5 %) was recorded in the plantation done during last week of May or first week of June. Even in the adjoining area i.e. in Burhanpur in Madhya Pradesh, similar trend was observed.

8.2.14 Characterization of bacterial endophytes and their role in management of grapevine diseases

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To manage grapevine diseases,endophytic bacteria (EBs) were isolated and evaluated for their biocontrol potential against *Colletotrichum gloeosporioides*, *Xanthomonascampestris* pv. *viticola,* the causal agents of anthracnose and bacterial leaf spot diseases, respectively.

Total45EBs were isolated from the different plant parts *viz*., berry, root, leaf, bark, cane, subcane and petioles of different grapevine varieties on nutrient agar medium. These EBs were characterized based on colony structure, spore morphology, biochemical tests and 16S rRNA sequence information.

Grape is an important fruit crop grown in India. It is severely affected by major diseases like downy mildew, powdery mildew, anthracnose, and bacterial leaf spot (BLS) under favourable climatic conditions. Among these, bacterial leaf spots disease (C.O: *Xanthomonas campestris* pv. *viticola*)and anthracnose (*Colletotrichumgloeosporioides*) are becoming the most devasting diseases in grape growing areas in India. A total of 16 EBs were isolated from grapevine (*Vitisvinifera)*cv. Muscat from Tamil Nadu and Cabernet Sauvignon from experimental farm of ICAR-NRC for Grapes, Pune. By using immature and mature berries of grapevine *cv.* Muscat and roots of grapevine *cv.,* Cabernet Sauvignon. Among 16 isolates, 15 were found to be Gram positive and 1 isolate was found Gram negative. Antagonistic activity of 16 bacterial endophytes inhibited the growth of phytopathogenic bacteria, *Xanthomonas campestris* pv. *viticola*. All sixteen endophytic bacterial isolates were compatible with fungicides such as Copper oxychloride 50%WP (2.4 g/L), Kasugamycin 5% + Copper Oxychloride 45%WP (0.75 g/L), Sulphur (2g/L), Metrafenone 500 G/L (0.25 ml/L) and Copper Sulphate 47.15% + Mancozeb 30% (5g/L). Additionally, 29 EBs were isolated i.e. 10 from bark, 5 from cane, 2 from subcane, and 1 from petiole of cv. Manik Chaman, 7 from leaf and 1 from berry of cv. Sonaka Seedless and three from seeds of cv. Ribier. These 29 bacterial endophytes were characterized and found prominent isolates against *X. campestris* pv. *viticola* and *C. gloeosporioidesin vitro*.

Bacterial endophytes strongly inhibited the growth of *C. gloeosporioides* and *X. campestris* pv. *viticola* under *in-vitro* conditions. Based on 16S rRNA sequence, bacterial endophytes belong to the genus *Bacillus*.

8.2.15 Improvising effective application of pre and post emergence herbicides through drip irrigation system in onion

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Onion due to its cylindrical upright leaves do not shade the soil and results in Un-controlled weed growth that reduces the bulb yield up to 40-80% depending upon the nature of intensity and duration of weed competition in the onion field. Hand weeding and herbicide application is a common method of weed control adopted by farmers. Therefore, a study was conducted to control the monocot as well as dicot weed population during *kharif*season in onion bulb crop by the application of herbicides through drip irrigation with eight number of treatments *viz*. T1: Ready mix formulation of propaquizafop 5% + oxyflurofen 12% EC @ 0.800 l/ha application through drip at 20 days after transplanting; T2: Pendimethalin 30 % EC @ 1.5 l/ha application through drip before transplanting; one hand weeding at 30 days after transplanting; 0.500 l/ha ready mix formulation of propaquizafop 5% + oxyflurofen 12% w/w EC application through drip at 35-40 days after transplanting; T3: Oxyflurofen 23.5% EC @0.600 l/ha application through drip before transplanting; one hand weeding at 30 days after transplanting; oxyflurofen 23.5% EC @ 0.600 l/ha at through drip at 35 – 40 days after transplanting; T4: Oxyflurofen 23.5% EC @ 0.600 l/ha application through drip before transplanting; one hand weeding at 30 days after transplanting; quizalofop ethyl 5% EC @ 0.800 l/ha through drip at 35 – 40 days after transplanting; T5: Pendimethalin 30 % EC @ 1.5 l/ha application through drip before transplanting; one hand weeding at 30 days after transplanting; quizalofop ethyl 5% EC @ 0.800 l/ha through drip application at 35 – 40 days after transplanting; T6: Combined spray of oxyflurofen @ 0.300 l/ha and quizalofop ethyl @ 0.600 l/ha application through drip before planting; one hand weeding at 30 days after transplanting; combined spray of oxyflurofen @ 0.300 l/ha and quizalofop ethyl @ 0.600 l/ha application through drip at 35 – 40 days after transplanting; T7: Weed free check (3 hand weedings) and T8: Weedy check and the field experiment was conducted on onion variety Agrifound Dark Red during *kharif*, 2018, 2019 and 2021 at RRS Nashik,

The three years combined results revealed that the treatment (Three times hand weeding) performed superior over other treatments in terms of highest weed control efficiency, gross yield and marketable yield with benefit: cost ratio (2.41:1.0). Among the herbicide treatments through drip irrigation, the treatment (Pendimethalin 30 % EC @ 1.5 L/ha application through drip before transplanting; one hand weeding at 30 days after transplanting; 0.500 L /ha ready mix formulation of propaquizafop 5% + oxyflurofen 12% w/w EC application through drip at 35-40 days after transplanting) recorded highest weed control efficiency (77.53%) and marketable yield (115.93 q/ha) with benefit: cost ratio (2.56:1.0).

8.2.16 Management of diseases and thrips of onion seed crop through different fungicides and insecticides

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To treatment combination of insecticide & fungicide. Onion is one of the export oriented bulbous vegetable crop grown in the country. Onion seed crop suffers mainly from stemphylium blight, purple blotch and thrips.In view of theabove problems field trial was conducted at Regional Research Station, National Horticultural Research and Development Foundation, Nashik, Maharastra during *rab*i 2019-20, 2020-21 and 2021-22 on onion variety NHRDF-Fursungi with the objective to find out the suitable spray schedule for management of foliar diseases and thrips of onion seed crop. Randomized Block Design was followed with three replications with the data revealed that treatment T_1 (*T. viride* @ 5kg/ha at planting time in soil + spray of propineb @ 2g/L + fipronil @ 1ml/L at 45 DAP + copper oxychloride @ 3g/L + carbosulphan @ 2ml/L at 60 DAP + mancozeb @ 2.5g/L + profenofos @ 1ml/L at 75 DAP + carbendazim @ 1g/L + cypermethrin @ 1ml/L at 90 DAP) performed superior with lowest incidence (61.11%) with intensity (9.87%) of stemphylium blight as well as lowest incidence (18.89) with intensity (1.12%) of purple blotch at 90 DAP while lowest thrips foliage damage (32.69%) was recorded in treatment T_4 (*T. viride* @ 5kg/ha at planting time in soil + spray of fipronil @ 1ml/L at 45 DAP + carbosulphan @ 2ml/L at 60 DAP + profenofos @ 1 ml/L at 75 DAP + cypermethrin @ 1 ml/L at 90 DAP) at 90 DAP. The highest seed yield (5.97 q/ha) as well as test weight of 1000 seed (3.46) was recorded in T_1.

8.2.17 Economic Threshold Level for Thrips (*Thripstabaci* L.)Onion Bulb Crop

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The onion thrips, *T. tabaci* feeds directly on leaves, causing silver blotches and premature senescence as well as distorted and undersized bulbs that reduced yield by 30-50% and is considered as a limiting factor for the onion bulb yield as well as reducing its quality. The field experiment was conducted at Regional Research Station, Nashik during *rabi*, 2019-20 and 2020-21 seasons. Seedlings of onion variety NHRDF Red-4 were transplanted in a bed having size of 3m x 1.2m at 15cm X 10cm spacing. The several treatment was replicated three times and arranged in completely randomized block design. Seven treatments for thrips number (nymphs/plant) were maintained by spraying the insecticide fipronil 5% SC @ 1.0 ml/L. In first treatment spray of fipronil @1.0 ml/L were given when more than 5 thrips (nymphs/plant) appeared. In second treatment spray of fipronil @ 1.0 ml/L were given when more than 10 thrips (nymphs/plant) appeared. In third treatment spray of fipronil @ 1.0 ml/L were given when more than 15 thrips (nymphs/plant) appeared. In fourth treatment spray of fipronil @ 1.0 ml/L were given when more than 20 thrips (nymphs/plant) appeared. In fifth treatment spray of fipronil @ 1.0 ml/L were given when more than 25 thrips (nymphs/plant) appeared. In sixth treatment spray of fipronil @ 1.0 ml/L were given when more than 35 thrips (nymphs/plant) appeared. In seventh treatment no spray were given and it was treated as control plot. A total of 6 sprays were given to maintain thrips population below 5 thrips (nymphs/plant) in first treatment, 5 sprays were given to maintain thrips population below 10 and 15 thrips (nymphs/plant) in second and third treatment 4 sprays were given to maintain thrips population below 20 and 25 thrips (nymphs/plant) in fourth and fifth treatments 3 sprays were given to maintain thrips population below 35 thrips (nymphs/plant) in sixth treatment and no spray were given in (control) for comparing the loss of bulb yield in different treatments.

On the basis of means of two years result revealed that, the economic injury level (EIL) of thrips in onion bulb crop was found to be 17.39 thrips/plant. The economic threshold level (ETL) of thrips in onion bulb crop was worked out as 13 thrips/plant. Economic Thresholds were calculated with best yield infestation relationship which was found at 50 days after transplanting and control expenditure required for six insecticide sprays. Market price of onion was taken Rs. 1152/= per quintal, which was average of two years.

8.2.18 Impact of non silica and silica based sticker with insecticides against onion thrips

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Experiment was carried out to find out the impact of non silica and silica based sticker on the efficacy of insecticides against onion thrips (*Thripstabaci*L). Onion (*Allium cepa*L.) belongs to the family Amaryllidace (*Alliaceae*) is one of the most important commercial vegetable and condiment crop grown in India. It is consumed throughout the year India is the second largest onion producing country in the world, next only to China.

Onion thrips (*Thripstabaci* L.) is a serious pest of onion crop and losses are reported to be high as 90%. Thrips in onion are difficult to control because of succulent nature of leaves, which prevents spray solution reaching the pests and also due to hiding habit of thrips in central axis near the bulb.Sticker reduces the surface tension of spray solution and gives an ideal coverage and penetration between the leaves. Silica based surfactant improving the efficacy of insecticides that have systemic translaminar movement within onion plants to control onion thrips. Considering the above problems field trials were conducted in two consecutive years during *rabi*2017-18 and 2018-19 on onion variety Agrifound Light Red at RRS, National Horticultural Research and Development Foundation (NHRDF), Nashik, Maharashtra (India).The experiment was arranged of 7 treatments with 3 replications in Randomized Block Design treatments evaluated were T_1 (Deltamethrin @1.0ml/L+ non silica based sticker @0.5ml/L), T_2 (Deltamethrin @1.0ml/L+ silica based sticker @0.5 ml/L), T_3 (Lambdacyhalothrin@1.0ml/L+ non silica based sticker @ 0.5ml/L), T_4 (Lambdacyhalothrin@1.0ml/L+ silica based sticker @0.5ml/L, T_5 (Fipronil@1.0ml/L+ non silica based sticker @0.5ml/L) T_6 (Fipronil@1.0ml/L+ silica based sticker @0.5ml/L) and T_7 (Control). The applications were started at 30 DAT and a total of 4 sprays were given at 15 days intervals. The data on thrips population (nymphs/plant) were counted with the help of hand lance on 10 plants selected randomly in each treatment atfifteen days intervals before and after 5 days each spray. Result showed that over all lowest mean thrips population (5.37nymphs/plant) were recorded in spray of Fipronil @1.0 ml/L + silica based sticker as well as highest gross yield (342.24q/ha) and marketable yield (326.99q/ha).The B:C ratio (9.11:1) was also recorded in the same treatment. Significantly highest thrips population and lowest yield was recorded in control treatment. The efficacy of insecticides was improved by addition of silica based sticker and minimizing thrips population as well as increased the yield of onion bulbs.

TECHNICAL SESSION-9

HUMAN RESOURCE DEVELOPMENT AND DIFFUSION OF KNOWLEDGE FOR TECHNOLOGICAL CHANGES FOR CLIMATE RESILIENT AND SUSTAINABLE DEVELOPMENT OF HORTICULTURE

9.1 Keynote Lectures

9.1.1 Skill and knowledge optimization for production of horticultural crops

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The distinctive climate of India, ensures production of diverse varieties of horticulture crops. Our country produced 341.6 million metric tonnes of fruits, vegetables and other horticulture crops from an area of 27.74 million ha (2022-23, 1st estm.). India is one of the top producers of fruits, vegetables, spices, plantation crops, medicinal & aromatic plants. The agricultural exports from India touched their highest ever mark by crossing US$ 50.2 billion in the financial year 2022-23. Our National Agriculture Research and Education System has succeeded in development of several varieties, production and protection technologies and provided knowledge powered solutions in horticulture, has made impact. In the current scenario of climate change and limited available resources, the challenges are complex for sustainable agriculture. The big challenge being faced relates for increasing yield and reduce average cost, therefore it needs to upgrade technology in many priority crops of horticulture sector. Application of biotechnology in agriculture through genetic breakthrough and genetic enhancement will play an important role in shaping future of agriculture. Horticultural knowledge contributes greatly to develop new varieties, plant architecture, disease free quality seeds and planting material, health management, harvesting, handling, efficient machines and tools. These technologies are going to set the pace further for the development of horticulture in diverse agro-climatic conditions enabling the production of a wide array of crops ranging from tropical to temperate fruits.

Horticulture development in the country has evolved through various process of growth. The current phase of growth is mix of new innovations and knowledge with target to achieve higher profitability. There is a focus on creation of knowledge through research and its dissemination through education and training for large scale adoption. The generation of new knowledge of hybrids, micro-irrigation, protected cultivation, plant architecture and plant health management using diagnostics have paved the way. Resultantly knowledge has been adopted and there is unprecedented growth in many of horticultural commodities. Knowledge with respect to the value of product is also essential to create better consumer base. Research system may increase the supply of new knowledge and technology and dissemination would be effective through skilling and new tools of digitalization in agriculture.

Knowledge skilling and dissemination happens through extension system, which comprise of 731 Farm Advisory Centres (KVK's) play a critical connecting role as knowledge dissemination centres in food and agricultural innovation systems. Apart from extension of latest technical know-how such knowledge centres should help local communities to meet their needs and link them to scientific research and input and output markets also. *Pradhan Mantri Kaushal Vikas Yojana* (PMKVY) under Ministry of Skill Development and Entrepreneurship promotes skilling of manpower in various sectors including agriculture through the Agriculture Sector Skill Council. Recognition of Prior Learning (RPL) under PMKVY has been able to undertake up-skilling of farmers via bridge course training through some of the projects. The scheme is being implemented across the country spanning 37 sectors including agriculture sector where the horticulture is in prominance. The beneficiaries are being oriented in skills such as 'Group Farming Practitioner' which enables farmers to increase productivity and income by establishing market linkages and buy – back arrangements. Beneficiaries are being enrolled pan India including for job roles such as Organic Grower, Floriculturist, Gardener and fruit crops cultivator etc.

The present shift noticed in horticulture is knowledge driven and has taken place from low tech to high-tech interventions such as protected cultivation, high density planting system in fruit crops, root stock technology, mechanization, micro-propagation, precision farming will reduce average cost of production, enhance farmer's income and address disabilities for upscaling them. Further, without improving efficiency of water use in agriculture through modern method of irrigation (drip, sprinkler, sensors) the country cannot address stress on water use and meet future water requirement.Role of frontier technologies such as biotechnology, nanotechnology, drone technology, ICT etc. have emerged as important tools in accelerating growth in agriculture including horticulture. In the changing scenario of food, nutrition, health and environment security, horticulture is required to be made more vibrant and competitive based on novel approaches and initiatives which are primarily knowledge driven, where skill and knowledge optimization is going to play greater role to address emerging challenges and meet future needs.

9.2 Oral Presentation

9.2.1 Impact of ICAR-DOGR varieties and technologies in tribal belts of Maharashtra

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Onion and garlic are important cash crops which can improve livelihood of the farmers. They also play a crucial role in food and nutritional security of tribals. The tribal belts of Nandurbar in Maharashtra has congenial climatic conditions for production of onion and garlic at commercial level, but cultivation of these crops was limited to the kitchen garden before the initiation of Tribal Sub Plan (TSP) in this area by ICAR-DOGR. Under TSP, systematic effort was undertaken to improve the area and production of onion and garlic by careful application of improved technologies.About 1410 tribal farmers were selected in a form of 141 groups under TSP in Nandurbar and Pune districts of Maharashtra. Each group undertook demonstrations on onion and garlic cultivation in one acre of land in Navapur, Akkalkuwa and Dhadgaon talukas of Nandurbar whereas, Khed and Ambegaon talukas of Pune. A total of 819 field demonstrations on newly improved varieties of onion and garlic and improved production and protection technologies were undertaken. As a result onion and garlic are giving more profit than traditionally grown crops in these areas. Farmers have earned a net income of Rs. 0.70-0.80 lakh per acre by production of about 120 q bulbs of onion variety Bhima Shakti/ Bhima Kiran/ Bhima Light Red during *rabi* whereas, earned same net income by production of about 85 q bulbs of Bhima Super/ Bhima Dark Red in *kharif*. Farmers have earned 0.60-0.80 lakh per acre net income by production of about 2 q seeds per acre of Bhima Kiran/ Bhima Shakti/ Bhima Light Red/ Bhima Super/ Bhima Dark Red. From garlic cultivation, Rs. 0.80-1.00 lakh per acre net income is earned by production of about 35 q bulbs per acre of Bhima Purple/ Bhima Omkar. Impact assessment of technological interventions was carried out to evaluate change in onion and garlic production, productivity and profitability as wellasknowledgeoftribalfarmers. The production and productivity of onion in Nandurbar has been increased to 91% and 38%, respectively after initiation of TSP. Socio-economic status of selected farmers under TSP have been significantly improved due to the technological intervention in onion and garlic.

9.2.2 Utilisation of oil palm phytonutrients for preparation of nutritional rich food products

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The nutritional status of population is one of the essential factors which briefs the social and economic development of a nation. However, many segments of the country suffering from one or more nutrient deficiencies, which pose serious health issues. To address the issue, food fortification which is a practice of increasing the required micronutrients in the food product to improve its nutritional quality has been introduced to prevent and control the micronutrient deficiencies. Palm oil is an edible oil extracted from oil palm fruits which is rich in phytonutrients such as retinol, â-carotene (vitamin A),

vitamin E (tocopherols and tocotrienols) and triglycerides (fatty acids such as palmitic acid, oleic, and linoleic acid) contents. Beverages and confectionary foods like margarine, bread, biscuits, ice cream, chocolates etc. that can be fortified with oil palm phytonutrients. Retinyl palmitate has been used as vitamin A fortificant for food including vegetable oil, rice, and other cereal flours. The fortification of wheat-based cookies (biscuits) with red palm oil has significantly increased plasma retinol and â-carotene concentrations in school aged-children. Moreover, palm oil is used majorly in margarines and shortenings because it is naturally semi-solid. As high palmitic acid content facilitates good aeration of fat and sugar therefore, 50–100% palm oil can be used in cake margarine. Thus, this study reviewed the potential use of oil palm phytonutrients in food industries as a food fortificant.

9.2.3 Banana: A successful intervention to change the livelihood of tribal farmers in valsad district of South Gujarat

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Banana is an important crop for subsistence of farmers, and ensures year round security for food or income. Govt. of India had implemented Tribal Sub Plan (TSP) for securing human resources development by substantial reduction in poverty and unemployment, creation of productive assets and income generating opportunities among tribal population through dissemination of technologies from research station to farmer’s field. Valsad districts of South Gujarat region having more than 50% tribal population. Most of farmers in both districts comes under small farmer category with very less land holding (1 to 4 ha) and growing field and vegetables crops with rotations. Main source of income was agriculture and animal husbandry and banana was a minor fruit crop. Average annual income of farmers from different crops range between Rs. 0.50 to 1.10 lakh/ha.

In 2014-15, scientists of Gandevi selected Valsad district and identified Kaprada block for cultivation of banana. Gandevi centre had implemented more than 100 FLD’s of different technologies to the tribal farmers from 2014-15 to 2019-20. The demonstration of banana was implemented in Khutli, Jamgabhan, Jogvel, Kurgam and Vadadha villages of Valsad district. Technology demonstrations with 500 to 1200 tissue culture banana plants cv. Grand Naine was carried out with inputs like chemical fertilizers, different biofertilizers, Novel organic liquid nutrient, Trichoderma, Pseudomonas and blue polythene bag (sleeve), sprayer pumps, *etc*. Also, high density plantation with pair row method and intercropping with vegetable were demonstrated in FLD’s villages to increase additional profit at early stage of banana crop.

Due to AICRP technology intervention during last 5-6 years, farmers got bunch yield from 14-20 kg/plant including ratoon crop with fruit price between Rs. 6 to 10/kg depending upon area and management practices under available resources. Average expenditure for banana cultivation was estimated between Rs. 2.0 to 2.50 lakh/ha and farmers obtained income ranged from Rs. 4.00 4.80 /ha. Therefore, tribal farmers could earn net profit between Rs. 2.00 to 2.30 lakh/ha. Besides this, farmers could receive additional income between Rs. 10,000-15,000/- per annum from intercropping of vegetables in banana without any extra cost. This initiative with technology demonstrations and extension awareness programmes worked as a catalyst and inspired other farmers in nearly by villages towards banana

cultivation resulted in enhancement in banana acreage and production up to 20-25% in Valsad district in last 5-6 years. Now, more than 550 young farmers has initiated cultivation of banana and getting 30-50% higher return than conventional farming of field crops. As well, some young farmers have started banana procurement and marketing of banana. As new development from 2020-21, the demonstration of banana macro-propagated plants has initiated at existing tribal farmers field along with tissue culture plants.

9.2.4 Improvement of bitter Gourd through tissue culture (*Momordica Charantia* L.)

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Bitter gourd (*Momordicacharantia* L.) belongs to the family Cucurbiteceae. It is widely consumed as a vegetable, commonly known as karela or bitter melon. Bitter gourd contains bright red seedsdue to high lycopene, a pigment that can be used as an artificial food colorant.

Thefruits of bitter gourd contain nutritionally useful essential minerals and amino acids. It has properties whichreduces the blood glucose, antitumor activity and antispermatogenic activities. It has also includealkaloids, insulin like peptides, and a mixture of steroidal sapogenins known as charantin.Traditional breeding for varietal improvement of any crop is timeconsuming. Improvement and development of new varieties of this crop arenecessary which could be done through the applications of modern techniques of biotechnology especially tissue culture. A balance between auxin and cytokinin determines the *in vitro* regenerationof plants grown in artificial medium. Type of explants, media composition, growthconditions, genotypes and physiological condition of the explants affect callusinduction and plant regeneration. A balance between auxin and cytokinin determines the *in vitro* regenerationof plants grown in artificial medium. Type of explants, media composition, growthconditions, genotypes and physiological condition of the explants affect callusinduction and plant regeneration. Therefore, the best growth condition, suitableexplants and genotypes are needed for large scale production of plants in *in vitro*.

9.2.5 Organic nutrient management for enhancing growth and yield of rabi onion (*Allium cepa* L.)

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Field experiments were conducted during the Rabi season of the academic year 2021–2022, a study was carried out at the research farm of the Nalanda College of Horticulture at Noorsarai, Nalanda (Bihar–803113) on the topic entitled “Study on Organic Nutrient Management for enhancing Growth & Yield of Rabi Onion (*Allium cepa* L.)”. The fertility of the soil is declining due to the hazardous use of Agro-chemicals, and the issue of climate change also negatively impacts Agriculture in various ways.The experiment was laid out in simple random block design with(combinations of organic manures viz, farm yard manure (FYM), poultry manure (PM), vermicompost (VC) were employed as nitrogen sources) while chemical fertilizer was used to balance the amounts of P_2O_5 and K_2O, influenced the bulb yield, nutrient uptake, soil fertility and paid higher returns compared to other treatmentsOut of the ten treatments, two of the treatments, i.e., T_{10} (25 % N through Vermicompost + 75 % N through Poultry manure) followed byT_6 (50 % N through FYM + 50 % N through Poultry manure) resulted in higher growth & yield of Rabi Onion. An increase in plant height (46.05 cm), bulb diameter (7.71 cm), average bulb weight (87.6 g) and total yield ha-1 (387.39 tones) was observed in different organic treatments as compared to the control.

Among all the treatments, the Treatment T_{10} (25 % N through Vermicompost + 75 % N through Poultry manure) onion was found to be the best for obtaining better growth, optimum yield, better quality produce as well as higher net returns and it might be recommended for climatic condition of Bihar. Thus, the experiment’s findings can be deduced that soil nutrient in form of organic manure can greatly improve the soil & plant health making the system sustainable.

9.2.6 Speed breeding of horticultural crops through genome editing

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The breeding cycles of horticulture crops are generally long, requiring prolonged breeding programmes and years of effort on the part of breeders to produce and introduce enhanced cultivars. The process for developing climate-resilient elite varieties typically covers several years across various crop types. The insufficient utilisation of genetic information can be attributed to obsolete phenotyping techniques and time-intensive cultivation methods that haven’t kept up with the advancements in high-throughput genotyping tools. The gradual nature of traditional plant breeding can be attributed, in part, to the extended duration necessary to fulfil the life cycle of the plant. Plants suffer from biotic and abiotic stress, reducing productivity and yield.The employment of contemporary methodologies in genome

editing, such as CRISPR, TALENs, ZFNs, and Meganucleases, facilitates the ability to perform editing with high precision at the targeted location. The broad applicability of genome editing tools renders them valuable in various domains, including crop enhancement, gene functional investigations, pathway exploration, genetic analyses, epigenetic research, among others. Genome editing technologies have been implemented in many horticultural crops to enhance crop productivity. The mentioned technologies exhibit a high degree of precision and are not subject to breeding constraints such as unexplored germplasm resources. Moreover, they significantly reduce the duration of breeding cycles from several decades to a few years, thereby enabling the fulfilment of global demands. The utilisation of genome editing in the horticultural sector has demonstrated promising prospects for the creation of crops that possess enhanced resistance to biotic and abiotic stressors, increased yield, and improved nutritional profiles.

9.2.7 Influence of chemicals and plant growth regulators on morphophysiological and yield parameters of Ashwagandha (*Withania somnifera* (L.) Dunal)

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Ashwagandha is one of the most important medicinal plants required in allopathic, ayurvedic and unani system of medicines. It is considered to be one of the best rejuvenating agents. Withanine and somniferine are the two important alkaloids of Ashwagandha. Different plant parts of the plant possess activities such as amoebicide, anodyne, abortifacient, bactericide, contraceptive, diuretic, emmenagogue, fungicide, narcotic, pediculicide, sedative, spasmolytic, adaptogenic and tonic. For better establishment of Ashwagandha under normal climatic conditions, the common practice is to sow the seeds directly in the field. The germination potential of the seeds has been reported to be very low. Propagation by natural re- seeding is thus no longer sufficient to guarantee the survival of this plant. Various chemicals and growth regulators play an important role in seed germination and seedling establishment. The purpose of the experiment was to identify the superior chemicals/growth regulators to obtain optimum morpho-physiological and yield parameters of Ashwagandha. The variety used for the present investigation was Gujarat Anand Ashwagandha – 1. The seeds were subjected to eleven treatments consisting of soaking in plant growth regulators, (GA_3 and kinetin, each of 250 and 500 mg/l for 6 hours), cow urine (soaking with 6 and 12 hours), chemicals ($NaNO_3$ and KNO_3, each of 4000 and 8000 mg/l for 6 hours) and soaking in distilled water for 6 hours as control. Results revealed that the seeds treated with KNO_3 @ 4000 mg/l for 6 hours enhanced the number of leaves per plant, number of shoot branches, CGR, RGR, AGR and root yield per plot while the treatment with $NaNO_3$ @ 8000 mg/l for 6 hours enhanced the leaf area, leaf area index, root branches, number of berries per plant and seed yield per plot.

9.2.8 Precise water and nutrients management in horticulture crops is need of hour for improved livelihood and nutrition

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India is basket of all Horticulture, all temperate, sub tropical and tropical horticulture Fruits, Vegetables, Flowers, Spices, Medicinal and aromatic, Plantation crops are cultivated. In India total area under all Horticulture crops is 2,77,38,000 ha and total production from it is 34,14,96,000 MT (excluding honey). It's good all crops are cultivated in India, though area is sizeable under horticulture crops however productivity is low. It is just 12.31 MT / ha. Mostly it is cultivated conventionally except few crops.

India is on top in population in world, every year population is increasing and land area is reducing. It is alarming to improve productivity in limited resources. Water scarcity, electricity availability, availability of labours in farming are major constraints these can also affect production in conventional cultivation. To overcome these problems and to get more production adoption of Drip irrigation is best solution. Age of this technology is more than 35 years. In India total area under drip irrigation is just 60 Lakh ha. Means out of total horticulture area only 21.63 % area has brought under drip irrigation technology.

In conventional farming ow productivity is due low inputs use efficiency. Water and Nutrients plays important contribution in getting higher yield n hence it's precise management is important to get more production of excellent quality. Water use efficiency in flood irrigation is 30 - 35 % and fertilizer use efficiency of conventional fertilizer is about 40 – 50 %. Application of the two inputs with drip irrigation gives efficiency more than 90 %. If both you very precisely with sensors used Automation n fertigation water n fertilizers use efficiency can achieve 95 + %.

Now people are aware of Health consciousness n look for quality fruits n vegetables. Drip Fertigation technology saves water, fertilizers, power, labour and produce more of excellent quality which will certainly help to improve livelihood n nutrition.

Hence Precise water and nutrients management in Horticulture Crops is need of hour for improved livelihood and nutrition.

9.2.9 Optimization of plant geometry with drip irrigation in rabi onion

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Irrigation scheduling is necessary for increased onion production in an Agro-climatic zone III A and B of Bihar where water is scarce gradually and a limiting factor for onion production. Field experiment were conducted during the Rabi season of 2013-14 and 2014-15 at the experimental farm, Nalanda College of Horticulture, Noorsarai, Nalanda. The objective was to standardization of plant geometry with drip irrigation and to study the yield performance and storability on onion in Nalanda region. The treatments consisted of factorial combination of three irrigation intervals (2, 4 and 6 days) and four population densities (20,00000, 13, 33, 333, 10,00000 and 6,66,666 plants/ha) corresponding to 10x5, 10x7.5, 10x10 and 15x10 cm respectively laid out in randomized block design replicated three times. Result revealed that highest marketable yield were significantly favoured by 2 days internal followed by 4 days. However, lower plant spacing 10x5 cm where found to increase plant height and minimum maturity days, consequently grass and marketable bulb yield was significantly higher with plant spacing 10x10 cm followed by 15x10 cm. The marketable bulb yield was significantly higher with interaction of T_7 (10x10 cm and 2 days irrigation interval) 1000000 plant density and 2 days irrigation interval than other treatment combinations. The results of study concluded with 2 days interval recommended irrigation with a plant density of 1000000 (10x10cm) plants per hectare for maximum onion bulb yield.

9.2.10 A review on effect of biofertilizers on vegetable production

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Biofertilizer is a natural product carrying living microorganisms derived from the root or cultivated soil. So they don't have any ill effect on soil health and environment. Biofertilizers enhances the soil fertility, seed germination and plant growth. Since past 50-60 years, soil management practices are mostly reliant on inorganic fertilizers, which decrease soil fertility and increased soil pollution resulting human health problems. Chemical fertilizers supply over nitrogen whereas bio-fertilizers provide in nitrogen along with certain growth promoting substances like hormones, vitamins, amino acids, etc, to the crops. Bio-fertilizers application in agriculture will have greater impact on organic agriculture and also on the control of environmental pollution, soil health improvement and reduction in chemical input use. The use of chemical nitrogen and phosphorus fertilizers at high levels had an adverse effect on the accumulation of $NH4^{+}$, NO_3^{-}, NO_2^{-} and PO_4^{-} in vegetable product tissues. The effects of chemical fertilizers are that they are toxic at higher doses. Bio-fertilizers, however, have no toxic effects. Bio-fertilizers are commonly called as microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes. Nitrogen fixing microbes comprises of symbiotic nitrogen fixing biofertilizers (including *Rhizobium, Azolla* etc.), free living nitrogen fixing biofertilizers such *Azotobacter, Cyanobacteria* blue green algae etc. and associative symbiotic nitrogen fixing biofertilizers (*Azospirillum*) whereas Phosphorus Solubilizing Bacteria (PSB) solubilise the fixed phosphorus. Application of biological fertilizer greatly involved in the accumulation of soil enzymes, which directly reflects on soil fertility index. The effective utilization of bio-fertilizers for crops not only provide economic benefits to the farmers but also improves and maintain the soil fertility and sustainability in natural soil ecosystem. Therefore, quality vegetable production directly depends upon using bio-fertilizers as well as organic in order to produce high yields with the best commodity quality without contamination and less accumulation with heavy metals.

9.2.11 Influence of inorganic fertilizers in conjunction with organic manures on growth, yield and quality of Broccoli (*Brassica oleracea* var. *Italica*)

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A research work was conducted in the research farm of Nalanda College Of Horticulture, Noorsarai, Nalanda (Bihar-803113) during Rabi season of academic year 2021-22 to study the Influence of Inorganic Fertilizers in conjunction with Organic Manures on Growth, Yield and Qualityof Broccoli (*Brassica oleracea* var. *Italica*) in a randomized block design with 11 treatments. Nutrients were applied through fertilizers and manures based on soil test.The Treatment, T_5 (50% RDN + 50% N as PM)recorded maximum values for plant height (37.41cm and 56.13cm), number of leaves per plant (16.53 and 20.11), leaf area (749.51cm^2 and 949.57 cm^2) at 45 DAT and 60DAT respectively. The treatment, T_5 also recorded least days for head initiation (44.60 DAT) and highest value for diameter of head (15.93cm), length of head (14.97cm), wt. of head/plant (407.16gm), wt. of head/plot (16.29Kg.), wt. of head/ha (150.65q.), vitamin C (92.43mg/g), dry matter (11.57%), gross returns (Rs.4,14,287.50/ha) and net returns (Rs. 3,19,448.00/ha). This was followed by treatment T_4 (50% RDN + 50% N as VC).Among all the treatments, the Treatment T_5(50% RDN + 50% N as PM)i.e., application of 50% recommended dose of N/ha with 50% N through poultry manure broccoli was found to be the best for obtaining better growth, optimum yield, better quality produce, highest net returnsas well as better soil healthand it might be recommended for climatic condition of Bihar.

9.2.12 Study of clay mineral transformation: A way towards smart management of resources

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Clay minerals play an important role in the nutrient cycling and physical properties of soil, and changes in their composition can affect soil health and productivity. Understanding the impacts of long-term nutrient management on clay mineral transformation in the soilcan have significant impacts on soil fertility, nutrient cycling, and overall soil health. Thus, aiding in sustainable soil management practices that maximize productivity while minimizing negative impacts on the environment.Understanding the mechanisms and consequences of clay mineral transformation in Typic Haplustepts can therefore inform strategies for precise use of resources, enhancing soil quality and productivity. A study was undertaken to study the clay mineral transformation under rice-wheat cropping system in a Typic

Haplusteptsat Bihar Agricultural College, Sabourwith the objective to study the effect of long-term application of inorganic and integrated nutrient management on clay mineral transformation. Long-term permanent plot experiment under rice-wheat cropping system was targeted under this study consisting of control (no fertilizer), 50% RDF both in rice and wheat , 75% RDF in rice and wheat, 100% RDF in rice and wheat, 50% RDF in rice and wheat + 50% N supplied through FYM, 75% through RDF in rice and wheat and 25% N supplied through FYM, 75% RDF in rice and wheat and 25% N supplied through wheat straw, 75% RDF in rice and wheat and 25% N supplied through green manure and farmer's practices. Dominant clay mineral in treatment under study wasillitic in nature. Formation of interstratified minerals (illite-vermiculite/illite-kaolinite) as well as transformation to vermiculite/chlorite was also observed through XRD analysis. Si-O stretching (650-900 cm^{-1}) and Al-OH/ Mg-OH/ Fe-OH stretching vibration (3400 cm^{-1}-3700 cm^{-1}) were invariably observed in all clay samples. Si-O-Al vibration (1030 cm^{-1}) and Al-OH-Si (1400 cm^{-1}) were also observed. SEM images further confirmed the clay transformation by showing changes in surface morphologies.

TECHNICAL SESSION-10

NATIONAL WORKSHOP ON PARADIGMS IN PRODUCTION AND UTILIZATIONOF BANANA WITH A SPECIAL REFERENCE TOTHE MANAGEMENT OF DISEASES

Panel Discussion: 1

Envisioning production and utilisation of Banana in scenario of changing cropping and weather coupled with enhanced demand

10.1 Keynote Lecture

10.1.1 Banana production and utilization in the scenario of climate change and knowledge creation

K.B. Patil
JISL, Jalgaon

10.1.2 Production of disease free and quality planting material in banana utilising tissue culture Technique

Anil B. Patil
JISL, Jalgaon

10.1.3 Harnessing the potential of banana processing, biomass utilization and boosting entrepreneurship

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Banana is a highly nutritious fruit, rich in bio-active compounds and globally accepted. However, the management of crop residues after the economic part's harvest remains a major issue in agriculture. This is particularly true for horticultural wastes, such as banana biomass, which generates a significant volume of pseudostems (30-35%), leaves, flowers, bracts (5%), and rhizomes (12-14%) after fruit harvest. Currently, less than 2% of these wastes are utilized for human consumption, while the remainder is wasted through incineration. With the growing importance of the circular economy concept, valorisation of these by-products can be a sustainable way to attain development in the fruit processing sector.This paper aims to discuss the utilization of biomass from various banana waste into novel and innovative high-value products through secondary and tertiary processing, such as starch, modified starch, fruit-based sugars, non-starch polysaccharides, cellulose, hydrogel, textile usage, nutraceutical, and pharmaceutical applications. Banana waste presents an opportunity for the creation of new business models and employment opportunities, thereby achieving global competitiveness and sustainable growth. Banana can be a suitable candidate for development of future food due to its inherent availability of bioactive components. Fine chemistry, innovation and development of niche markets coupled with the circular economy approach can manifold enhance the value of products. The application of new methods, processes and product achieves global competitiveness and sustainable growth through creation of new business models and employment opportunities.

10.1.4 Emerging technologies for plant health management in banana

Prakash Patil
AICRP-Fruits, ICAR-IIHR, Bengaluru

10.1.5 Effective dissemination of new knowledge on banana production and utilization

C. Karpagam
ICAR-NRCB, Trichy

10.1.6 NRCB-STCR-Fertilizer calculator – a farmer-friendly gadget for precise use of fertilizers in banana cultivation

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Banana production requires application of fertilizers in large quantities, since it is an exhaustive crop. The cost of fertilizer is the major component, which is more than 30% of the production cost. Farmers are applying fertilizers indiscriminately without soil analysis and also without any scientific requirements. In addition, there is a growing concern about the low use efficiency of nutrients which ranges from 20-50%. Such a low efficiency increases the cost of production and leads to severe environmental consequences. Impaired soil health and declined productive potential is primarily due to the imbalanced fertilizer application coupled with low organic manure application. This situation has led to multiple nutrient deficiencies of macro and micro nutrients and recently it was observed that severe micro-nutrients deficiencies for zinc, boron and iron in different banana growing soil. To overcome this indiscriminate fertilizer application and to increase the fertilizer use efficiency, ICAR-NRC for Banana has developed Fertilizer Tailoring Equations (STCR-fertilizer calculators), based on "Soil-Test-Crop-Response" (STCR) approach (Ramamoorthy et al., 1967), for optimizing the fertilizer requirement with increased productivity of the banana. Such STCR-fertilizer calculators have been developed for major commercial banana varieties and have been validated in different ACRIP (Tropical Fruits) centers and farmers' fields in different agro-climatic conditions. By adopting these fertilizer calculators, farmers can choose the banana yield target for which the fertilizer requirement can be worked out precisely. By this, the profitability of the banana farmers could be increased without affecting the soil health. Thus, these fertilizer calculators will go in long way in increasing the nutrient use efficiency, thereby banana farmers can be benefitted. In India, 35 million tons of banana is being produced from 9 lakh hectares, with the application of about 42 lakh tons of inorganic fertilizers, annually. By the year 2030, India has to produce 50 million tons of banana to cater to the needs of exploding population and for export purposes. For this, the requirement of inorganic fertilizers is estimated to be about 60 lakh tons. The cost of inorganic fertilizer is also increasing exorbitantly day by day. New economic reforms have suggested for the removal of subsidies given to inorganic fertilizers and at this present situation, the target of 50 million tons of banana production is likely to be out of reach. This situation is again aggravated by the indiscriminate and imbalanced use of inorganic fertilizers based on various blanket recommendations in different banana growing regions. This practice has led to deterioration of soil health in many areas. Banana production at the current yield levels is not sustainable and in the long run, causes significant depletion of soil nutrients. Hence, the development, validation, importance and effective utilization of these NRCB-STCR-fertilizer calculators have been discussed in this paper, in detail.

Panel Discussion-2

Dynamics of Changes in Pest and Diseases of Banana and Strategic Management Approaches

10.2 Keynote Lecture

10.2.1 National scenario of emerging diseases of banana and technological interventions for the effective management

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Banana, a major fruit crop grown in India is contributing 35 million tonnes annually from 0.96 million ha. We need to increase our per capita availability of banana from 63 gms per day per person to 100 gm per day per person by 2030. Biotic stresses especially Fusarium wilt- *Fusarium oxysporum* f.sp. *cubense* (*Foc*) (both race 1 and TR4 of *Foc*), Eumusae leaf spot(*Pseudocercospora eumusae*), bunchy top virus, cucumber mosaic virus and soft rot (*Pectobacterium carotovorum* and *Klebsiella variicola*) are the major delimiting factors of banana production in India. Wide occurrence of Fusarium wilt infecting Cavendish (Grand Naine) by *Foc* TR4 in Katihar and Purnea districts of Bihar, Uttar Pradesh (Faizabad) and West Bengal, and other virulent strain of *Foc* race 1 (VCG 0124) in Theni district of Tamil Nadu and Surat district of Gujarat have been reported and the incidence recorded was >40-50%. ICAR-NRCB has identified suitable alternatives resistant cultivars and biocontrol consortia to manage Cavendish infecting virulent Fusarium wilt strains. Similarly, for managing leaf spot, chemical, botanical and biocontrol strategies have been developed. Cucumber mosaic virus (CMV) is found to be the alarming problem especially in central parts of India as it re-emerged in an epidemic proportion during July-August 2020, in Jalgaon (Maharashtra) and Burhanpur (Madhya Pradesh), and subsequent occurrence during 2021 – 2022 caused devastation as almost 50 lakhs infected plants were uprooted by the farmers after second or third month of planting. The incidence ranged from 11 to 100% in many plantations. Besides, soft rot or rhizome rot caused by bacterial disease is yet another emerging problem during early stage of establishment (1-5 months of planting). By advent of technologies, use of Artificial Intelligence (AI) based monitoring of diseases to know the spread and develop decision support system, rapid detection kits for fast diagnosing and indexing the diseases (viruses), eco-friendly biocontrol consortia, clean planting material, clean and precision cultivation etc., would be better IDM practices in changing climate scenario to manage the dreadful diseases.

10.2.2 FUSICONT: A novel technique for management of wilt disease of banana

T. Damodaran
Director, ICAR-CISH, Lucknow

10.2.3 Current advances in the understanding and management of various important diseases of banana in India

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Bananas are known for its antiquity and are interwoven with Indian heritage and culture. The plants are considered as symbol of prosperity and fertility. Banana is a major fruit crop cultivated in 0.90 million hectares in India and its annual production is 33 million tonnes and hence become the largest banana producer in the world. However, productivity is concerned it stands behind the Indonesia, Guatemala, Ecuador and the reasons being are biotic and abiotic factors which include drought, low temperature, infestation by borers, scary beetles, and incidence of Fusarium wilt, leaf spot, bunchy top, bract mosaic, rhizome rot etc. Among different constraints listed, the fungal diseases particularly Fusarium wilt caused by *Fusarium oxysporum* f. sp. *cubense* (*Foc*)and eumusae leaf spot disease caused by *Mycosphaerella eumusae* are considered as major constraint of banana production and quality of banana fruits. The rhizome rot caused by *Klebsiella variicola* and *Erwinia* spp also results in 5-30% death of the plants at an early stage. Besides pre and postharvest diseases such as cigar end rot, pitting disease, finger rot, freckle spot, anthracnose and crown rot diseases are also posing serious problem by reducing the quality of the produce and decreasing the shelf life of banana which in turn hamper the export of banana to a distant market.

Of late, Fusarium wilt particularly Tropical race 4 strain of *Fusarium oxysporum* f.sp. *cubense* is becoming a major threat to banana industry in almost all the banana growing continents of the world affecting livelihood of millions of the people besides affecting economy of several banana exporting countries. In India too, this lethal disease (*Foc* R1 and TR4) is widespread in almost all the banana growing states of India and results in severe yield losses to the framers, abandoning of the *Foc* infested field, drastic reduction in area under banana cultivation particularly in Bihar, UP and West Bengal and shifting of cultivation to either non remunerative crops like maize or other varieties like Nendran and Red banana particularly in Theni district of Tamil Nadu. As these strains can spread through contaminated soil, planting materials, irrigation water, bunch stalk and implements, there is a possibility of movement of these deadly strain to other neighboring states which may cause huge yield loss and unemployment problems. Besides the Cavendish clones which occupy 52% of the total area under banana cultivation and contributing to 64% of the total banana production in India will be under serious threat.

The Eumusae leaf spot disease caused by *Mycosphaerella* spp is also becoming a major problem of banana production as it reduces the bunch weight by heavy defoliation as well as the quality of the fruits by causing premature and irregular ripening of the fruits in major banana producing states particularly in Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka, West Bengal, Odisha and Bihar. The crop loss due to leaf spot disease is ranged from 20 to 50%. In Maharashtra, particularly in Jalgaon district; the disease affects the crop even at one month after planting as against 6 months after planting in other states. The survey conducted in different banana growing states indicated that the maximum disease index of 90 –100% was observed in cultivars such as Cavendish group (Grand Naine, Mahalakshmi, Srimanthi and Robusta), Poovan (Mysore-AAB), Nendran (AAB), Hill banana (AAB), Monthan (ABB), Pachanadan (AAB) etc.

Similarly, the Rhizome rot disease is one of the major problems in banana (Musa spp.) cultivation, as it causes germination failure and death of early-stage plants particularly and the incidence was more during extreme summer or flooded condition. The tissue cultured plants are more susceptible than suckers and the varieties like Nendran, Grand Naine, Ney Poovan, Thellachakrakeli etc are more susceptible to this disease. Regarding pre and postharvest diseases, the diseases like Freckle and Pitting diseases reduces the quality of the fruit severely whereas the postharvest diseases such as anthracnose and crown rot caused by fungal pathogens *Lasiodiplodia theobromae* and *Colletotrichum musae* respectively cause 30-40% loss of saleable fruit and reduces the shelf life of banana drastically.

To manage these aforesaid diseases, different technologies including pathogen/race specific diagnostics, host plant resistance, chemical and biological control methods using PGPR possessing multiple functions, botanicals, economical and farmer friendly mass production methods, storage and delivery system for the effective biological control agents have been developed and validated. These above said technologies developed for the effective management of various diseases in banana are discussed in detail.

10.2.4 Integrated management of insect pest and virus vectors of banana for improved yield and fruit quality

Padmanabhan
Former Principal Scientist, ICAR-NRCB

10.2.5 Intensification of gene source of Fusarium wilt through harnessing the genetic diversity

Backiyarani
Senior Scientist, NRC on Banana, Trichy

10.2.6 Mutation breeding for generating Fusarium (TR4) resistant variety

M.S. Saraswathi
ICAR-NRCB, Trichy

10.2.7 Bacterial diseases of banana and its effective management

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Banana is a major fruit crop cultivated in 0.924 million ha and its annual production is 33.06 million tonnes which records the India as the largest banana producer of the globe. Besides, the crop contributes for food and nutritional security, and employment opportunities to millions of people, particularly to small farmers and landless labourers. Also it plays a key role in supporting Indian economy in terms of sale in domestic as well as export markets. However, production of the crop is largely affected by biotic and abiotic stresses. Among the former one, bacterial diseases such as *Xanthomonas* wilt (*Xanthomonas campestris* pv. *musacearum*), moko/bugtok wilt (*Ralstonia solanacearum*), banana blood disease (*R. syzygii* subsp. *celebesensis*), and soft rot/rhizome rot (*Pectobacterium* spp., *Dickeya* spp. and other genera) besides fungal and viral are found to be cause a huge yield loss.A survey conducted on bacterial diseases of banana in different banana growing states of India covering Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Maharastra, Gujarat, West Bengal, Uttra Pradesh and Bihar indicated a wide occurrence of only soft rot/rhizome rot disease. It is reported to cause 5-30% incidence in different commercial cultivars including Grand Naine, Red banana, Thella Chakkarakeli, Poovan, Nendran, Rasthali, Karpuravalli and AB-Neypoovan during early stage of their establishment (up to 6 month old). The major symptoms observed were yellowing and necrotic drying of leaves, rotting in rhizome and centre core which emitting foul smell and toppling of seedlings. Gardens planted with tissue culture plants were moreaffect bythe disease than sucker planted one. The disease causing agent reported generally is a *Pectobacteriam carotovorum*whileit is found to be a *Klebsiella variicola*in certain parts of the country (Loganathan *et al.* 2021). Management of the disease is mainly carried out in an integrated approach by involving cultural, biological and chemicals methods. In the presentation,current status, characterization of pathogen and management practices for rhizome rot disease in India and awareness created among banana stakeholders about the other bacterial diseases to prevent/quarantine the diseases, will be covered.

10.2.8 Micro irrigation for potato

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Potatoes are very sensitive to moisture stress. Some researchers conclude that the potato is among the most sensitive of all cultivated plant species when comparing moisture sensitivity. Potato has very shallow root system in comparison to other commercial crops. Approximately 85% of roots are located in the upper 30 cm of the soil. Similarly the roots are weak and during dry periods they have difficulty in penetrating hard soil layers in the profile. This makes their access to water difficult during dry periods. Both drip and sprinkler irrigation methods are suitable for Potato farming.

Drip irrigation

Inline drip system is suitable for Potato. The drip laterals are spaced on a skip row basis i.e. at 180 cm spacing where Potato is planted on ridges at 90 cm spacing. When the ridges are spaced at 1.2 m, an inline tube is placed at every row. Potato is also planted on broad raised beds 1.2 m wide. Here two rows are planted on the bed at 90 cm space between the two rows. And the drip line is placed in the center of the bed serving the rows on either side. In case of inline the entire strip is wetted by placing drippers at 40, 50 or 60 cm (based on soil texture) along the drip line.

Some of the benefits of drip irrigation for potato production are; yield increases under drip irrigation. Yield superiority in drip irrigated potato reaches up to 1.16 kg/plant in drip irrigated crop *vs.* 0.836 kg/plant in furrow irrigated crop. Trials have proved that there are significant differences for the number of tubers and total yield per plant in favor of drip irrigation. Water running down the furrow is eliminated. This reduces wastage due to seepage, and percolation and evaporation. Water saving up to 40% is recorded under drip system.

Sprinkler irrigation

Because of the fact that Potato is a tuber crop sprinkler irrigation is also found suitable for the crop. Using sprinkler water is applied every 3 or 5 days depending upon the soil texture and water holding duration of the soil. But irrigation with this system will create cyclic water excesses and shortages; both of which affect the growth and production of the crop. Irrigation efficiency is also lower (60%) than that of drip (90%). But many farmers choose Sprinkler system because of relatively lower investment cost. But effective fertigation is not possible thru Sprinkler system.

Different models of sprinklers of Jain are found suitable for Potato. One may select from Sprinkler models 5022 U, 501U, Super 10. The placement and discharges are given below.

	Sprinkler models and discharge	
Models	Sprinkler placement	Discharge
	M	lph
5022 U	10 x 10	360-720
501 U	6 x 6	168-288
Super 10	10 x 10	360-820

TECHNICAL SESSION-11

NATIONAL WORKSHOP ON DYNAMICS OF POTATO PRODUCTION AND UTILISATION WITH SPECIAL REFERENCE TO SEEDS AND DISEASE MANAGEMENT

Panel Discussion -1

Envisioning challenges & Opportunities in Potato Seed Production

11.1 Keynote Lecture

11.1.1 Emerging scenario of potato seed production in India

B.P. Singh
Former Director, CPRI, Shimla and Advisor, JSIL, Jalgaon

11.1.2 Technological changes in potato seed production

R.K. Singh
Principal Scientist, IIVR, Varanasi

11.1.3 Diagnostics in production of quality potato seed

Ravinder Kumar
Scientist, CPRI, Shimla

Panel Discussion -2

Dynamics of value chain Management in Potato for harnessing the potential in Potato

11.2 Keynote Lecture

11.2.1 Varietal development in potato & requirement for meeting demand of different sectors

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Introduction

Potato is the leading non-grain food product in the world after rice, wheat and maize. It belongs to the *Solanaceae* family and to the Solanum genus, which includes about 2000 species, of which about 235 are tuber bearing. It is known that the origin of the potato is the Andes of southern Peru and northern Bolivia. The commonly cultivated potato is a tetraploid and belongs to the species *Solanum tuberosum*, which includes two subspecies viz. ssp. tuberosum adapted to long days and ssp. andigena adapted to short days.

Potato breeding in India

Cultivated potato breeding approaches have always been difficult due to the complex genetic architecture and complex tetrasomic inheritance patterns. Variety development for potatoes in India was beset with numerous difficulties. All of the European varieties introduced in the country have been adapted to the long day, their multiplication in India led to the progressive accumulation of viral diseases, resulting in an accompanying decline in yield. To grow potato varieties suitable for India's subtropical conditions, the potato breeding program was launched in 1935 at the Potato Growing Station (PBS) in Shimla. In India, systematic potato breeding was initiated following the establishment of the Central Potato Research Institute (CPRI-now ICAR-CPRI) in 1949. The main goal of most potato breeding programs is to develop high-yielding varieties that are resistant to biotic and abiotic stresses and suitability for table and processing purposes.

The potato is a highly heterozygous crop, in which most of the economic traits are governed by both additive and non-additive gene actions. In the past Indian potato breeding program, parental choice was based primarily on phenotypic expression and the breeder's experience with the parental value of a particular genotype. Recently, several studies have been conducted to identify parents with good general combining ability for economic traits such as tuber yield and resistance to late blight. Such a good general combiner, namely JEX / A-680-16, has been widely used in various breeding programs.

Ecological zones and variety requirements

India has a variety of soil types and agricultural climatic conditions. Based on soil, climate, and other agronomic features, India is divided into eight potato regions. While these regions are located in two major potato growing regions, namely the North Indian hills and the Northern Indian plains, southern and North Bengal and the Sikkim hills and plateau are three specific problem areas. The following features of different agro-climatic zones are the basis for the development of potato varieties optimized for commercial use in these areas-

I. **North-western plains:** This zone requires short-day adapted, early bulking, heat tolerant, and late blight resistant varieties. For main crop variety, tolerance to frost is an added advantage.

II. **West-central plains:** Short-day adapted, early bulking varieties with moderate resistance to late blight and slow degeneration rate are desirable for this zone.

III. **North-eastern plains:** Short-day adapted, early bulking, late blight resistant varieties are best suited.

IV. **Plateau region:** Varieties suitable for this zone should be, early bulking with ability to tuberize under high temperatures, resistant to bacterial wilt, mites and potato tuber moth, and have slow rate of degeneration.

V. **North-western and central hills:** The varieties for this zone should be adapted to long days (14 hr day) and have high resistance to late blight and bacterial wilt.

VI. **North-eastern hills:** Varieties for this zone should be adapted to long day conditions and have high resistance to late blight and bacterial wilt.

VII. **Southern hills:** varieties with long day adaptation, early bulking, resistance to late blight and cyst nematodes are suitable for this zone.

VIII. **Sikkim and North Bengal hills:** Resistance to late blight and immunity to wart are major requirements of varieties for this zone. There is a distinct preference for red skin tubers.

Potato varieties for different purposes

1. Breeding improved table potato varieties for North Indian plains –

Subtropical plains accounts nearly 90% of the potato production of the country. Variety improvement programme for sub-tropical plains is located at Jalandhar, Modipuram and Patna centres of the ICAR-CPRI. All the three centers carry out the breeding programme independently keeping in view the specific variety requirement of their region. At Jalandhar, the aim of breeding programme is develop short duration early bulking varieties which could be cultivated as sandwitch crop between paddy and wheat crop providing high cropping intensity and profit to the farmers. At Modipuram, the breeding priorities includes to develop potato varieties for main crop season with moderate level of late blight resistance and good keeping quality. The breeding activity at Patna is meant to develop red skin medium maturing varieties with moderate level of late blight resistance to provide new option to the farmers of eastern plains of India, where red skin potatoes are preferred. The work done in the programme has led to the development of 32 improved potato varieties for subtropical plains as mentioned in table 1.

2. Breeding varieties for processing potatoes

Potatoes can be processed into a variety of products like chips, French fries, flakes and granules, etc. Potato flour is another product that can be used in baking industry, baby foods and as thickener and flavouring agent in soups and sauces. To keep the pace with rising demand for processing potatoes, the ICAR-CPRI, developed and released varieties Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Himsona, Kufri Frysona, Kufri Chipsona-4 and Kufri FryoM. These varieties are gradually occupying large areas of various regions for meeting the requirement of quality potatoes for processing.

3. Breeding for nutrient rich potatoes

The potato breeding programme now at ICAR-CPRI, Shimla focuses on development of biofortified potato varieties for â-carotene, total carotenoids, anthocyanin, ascorbic acid, resistant starch, phenols, micro nutrients like iron and zinc. The new variety Kufri Neelkanth is specialty potato variety having high anti-oxidants known to be beneficial for human health. Efforts have been initiated in this regard and populations up to advanced generations have been developed and will be released in near future as "Nutrient rich Potatoes".

Breeding tor biotic stress resistance

1. Breeding in relation to late blight

Late blight of potato caused by the oomycete fungus *Phytophthora infestans* (Mont.) de Bary is the most important disease of potato crop in temperate regions. High humidity, moderate temperature and cloudy days are congenial for its spread and development. In extreme cases of infection, yield losses up to 80-90% have been recorded. At ICAR-CPRI, breeding for field resistance was initiated using *S. verrucossum* in the year 1975 with *S. phureja* acting as a bridge species to enhance crossability. Parental lines sharing gene pool from wild and semi-cultivated Solanum species like *S. acaule*, *S. demissum*, *S. chacoence*, *S. hougassi*, *S. microdontum*, and *S. stoloniferum*, were developed. One major constraint of field resistance is its linkage with late plant maturity. In India, several late blight resistant varieties were developed for different regions.

2. Breeding in relation to virus diseases

Viruses are the important group of plant pathogens affecting quality potato production worldwide. They cause progressive degeneration of the crop, increasing with subsequent generations. Resistance to aphids (vectors of viruses), tolerance to PVX and PVY, tospovirus causing stem necrosis, resistance to viruses X, S, Y and leaf roll is also available in several Indian cultivars mentioned in table no. 1. It is necessary to develop the multiplex parents for the viral resistant breeding. ICAR-CPRI, Shimla has produced a triplex clone YY-6/3 C-11 carrying extreme resistance gene to Ry_{adg} in triplex dose to PVY using marker assisted selection (MAS).

3. Breeding in relation to potato wart

Potato wart is the most important quarantine disease in potato production caused by *Synchytrium endobioticum* and considered to be the most destructive fungal disease of potato widely distributed in the potato growing regions of the world. Systematic breeding programme for wart resistance in India started under the scheme "Investigation on wart disease of potato and breeding wart resistant varieties of potato" in 1961. Based on germplasm screening, many promising parental lines has been identified and many varieties (mentioned in table 1) released by ICAR-CPRI for above different biotic stress as well as other biotic stresses like bacterial wilt, charcoal rot and potato cyst nematode etc.

Breeding tor abiotic stress resistance:

1. **Breeding in relation to heat tolerance -** Heat stress in potato is influenced by genotype as well as environment. Selection of promising parents and development of superior crosses is important for obtaining heat tolerant high yielding progenies. In India, the work on response of potato plants to heat stress was started in 1984 with screening of germplasm collection. ICAR-CPRI has developed two heat tolerant varieties Kufri Surya and Kufri Kiran for growing in warmer areas.

2. **Breeding in relation to drought tolerance -** Considering future water scarcity, a programme to breed drought tolerant varieties was started in 2005. Breeding efforts for identification and release of drought tolerant/water use efficient varieties led to identification and release of one drought tolerant varieties Kufri Ganga for drought prone areas in north Indian plains.

3. **Breeding in relation to nitrogen use efficiency –** The research activity of variety improvement for developing nutrient use efficient variety is located at Jalandhar station of ICAR-CPRI. The work done in the programme has led to the development of one nitrogen use efficient variety Kufri Gaurav.

Potato breeding strategies

A potato variety is a group of identical plants produced asexually from a single genotype and is devoid of heritable variation during its propagation. Plants of potato variety are homogenous because they are produced asexually, and heterozygous, because they originate from a heterozygous individual. The terms cultivar and variety are synonyms of each other. Cultivated potato is tetraploid and highly heterozygous. It is perhaps an impossible task to combine all traits to obtain an ideal variety because of the complex heterozygous nature of potatoes. The new variety thus should be superior to existing in at least one important characteristic, without being significantly inferior to it in any other important traits. Heterosis is observed on crossing diverse parents. Hence, the breeding of potatoes involves hybridization between identified parents and the selection of superior clones from the segregating population. The genetic constitution of the genotype obtained following hybridization is fixed in the seedling stage and due to vegetative propagation the genetic constitution of the potato genotype with all its intra- and inter-locus interactions responsible for its phenotypic expression is maintained in the clonal generations. Hence, a clone if perceived desirable can be multiplied for commercial cultivation even though initially it may be present as a single plant.

The outline of the potato breeding methodology is depicted in Fig.

Conclusion

So concerted breeding efforts at the ICAR-Central Potato Research Institute have led to development of 69 improved potato varieties and one TPS population (92-PT-27) over years last 70 years, for

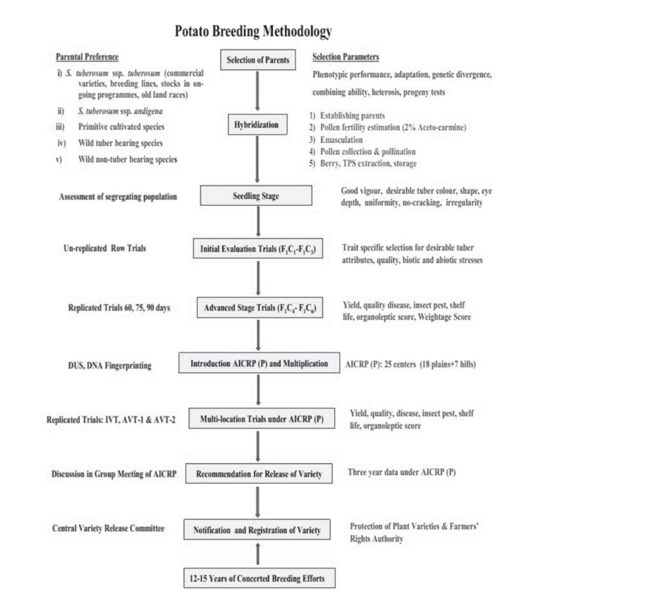

Fig. 1: The outline of potato breeding Methodology

cultivation in diverse agro-climatic zones of the country. Availability of indigenous varieties, good quality seeds and right package of agronomic practices triggered a revolution in potato productivity causing very fast growth in area, production and productivity.

Table 1: Salient feature of potato varieties released by ICAR-CPRI, Shimla

Name	Year of release	Areas of adaptation	Salient features
Kufri Kisan*	1958	North Indian plains	Maturity late; tubers white round, eyes deep and prominent eyebrows and flesh white.
Kufri Kuber*	1958	North Indian plains and plateau region	Maturity medium; tubers white ovoid, tapering towards the crown end, eyes medium deep, flesh white; resistant to PLRV and immune to PVY.
Kufri Kumar*	1958	North Indian hills	Maturity late; tubers white ovoid, tapering towards heel end, eyes fleet, flesh white; immune to wart and resistant to charcoal rot.
Kufri Kundan*	1958	North Indian hills	Maturity medium; tubers white round-ovoid, flattened, eyes medium deep, flesh cram; resistant to charcoal rot.
Kufri Red*	1958	North eastern plains	Maturity medium; tubers red round, eyes medium deep, and flesh yellow.
Kufri Safed*	1958	North Indian plains	Maturity late; tubers white round, eyes medium deep and red-purple, and flesh light yellow.
Kufri Neela*	1963	South IndianHills	Maturity late; tubers white ovoid, eyes medium deep, flesh white; resistant to cyst nematodes.
Kufri Sindhuri	1967	North Indian plains	Maturity late; tubers red round, eyes medium deep, flesh cream; moderately resistant to early blight and tolerant to PLRV.
Kufri Alankar*	1968	North Indian plains	Maturity medium; tubers white ovoid, eyes fleet, flesh white; moderately resistant to late blight.
Kufri Chamatkar*	1968	North Indian plains	Maturity late; tubers white round, eyes medium deep, flesh yellow; resistant to early blight, charcoal rot, and immune to wart.
Kufri Chandramukhi	1968	North Indian plains and plateau region	Maturity early; tubers white ovoid, slightly flattened, eyes fleet and flesh white.
Kufri Jeevan*	1968	North-Indian hills	Maturity late; tubers white ovoid, eyes fleet, flesh white; moderately resistant to late blight.
Kufri Jyoti	1968	Hills, plains and plateau region	Maturity medium; tubers white ovoid, eyes fleet, flesh white; moderately resistant to late blight and immune to wart.
Kufri Khasigaro*	1968	North-eastern hills	Maturity late; tubers white round-ovoid, eyes deep, flesh cream; moderately resistant to late blight and early blight.
Kufri Naveen*	1968	North-eastern hills	Maturity late; tubers white ovoid, eyes fleet, flesh white; moderately resistant to late blight and immune to wart.
Kufri Neelamani*	1968	South Indian hills	Maturity late; tubers white ovoid, flattened, eyes fleet, flesh white; moderately resistant to late blight.
Kufri Sheetman*	1968	North-western plains	Maturity medium; tubers white ovoid, eyes fleet, flesh cream; moderately resistant to charcoal rot and tolerant to frost.
Kufri Muthu*	1971	South Indian hills	Maturity medium; tubers white round-ovoid, eyes medium deep, flesh white; moderately resistant to late blight and immune to wart.
Kufri Lauvkar	1972	Plateau region	Maturity early; tubers white round, eyes fleet, flesh white; tolerant to heat.
Kufri Dewa*	1973	North Indian plains	Maturity late; tubers white round, eyes pink and medium deep, flesh cream; tolerant to frost.
Kufri Badshah	1979	North Indian plains and plateau region	Maturity medium; tubers white ovoid, eyes fleet, flesh white; moderately resistant to late blight, early blight, and PVX.
Kufri Bahar	1980	North Indian plains	Maturity medium; tubers white round-ovoid, eyes fleet, flesh white; immune to wart.
Kufri Lalima	1982	North Indian plains	Maturity medium; tubers red round, eyes medium deep, flesh white; moderately resistant to early blight and resistant to PVX.
Kufri Sherpa*	1983	North Bengal hills	Maturity medium; tubers white round flattened, eyes medium deep, flesh cream; moderately resistant to early blight and late blight, and immune to wart.

Kufri Swarna	1985	South Indian hills	Maturity medium; tubers white round-ovoid,eyes fleet, flesh white; moderately resistant to late blight and early blight, immune to wart, highly resistant to cyst nematodes.
Kufri Megha*	1989	North-eastern hills	Maturity late; tubers white round-ovoid, eyes fleet, flesh white; resistant to late blight.
Kufri Jawahar	1996	North Indian plains and plateau region	Maturity medium; tubers white round-ovoid, eyes fleet, flesh white; moderately resistant to late blight and immune to wart.
Kufri Sutlej	1996	North Indian plains	Maturity medium; tubers white ovoid, eyes fleet, flesh white; moderately resistant to late blight and immune to wart.
Kufri Ashoka	1996	North Indian plains	Maturity early; tubers white ovoid, eyes medium-deep, flesh white.
Kufri Pukhraj	1998	North Indian plains and plateau region	Maturity early; tubers white ovoid, slightly tapered, eyes fleet, flesh yellow; resistant to early blight; moderately resistant to late blight and immune to wart.
Kufri Chipsona-1	1998	North Indian plains	Maturity medium; tubers white ovoid, eyes fleet, flesh white; resistant to late blight; suitable for chips and French fries.
Kufri Chipsona-2	1998	North Indian plains	Maturity medium; tubers white round, eyes fleet, flesh cream; resistant to late blight; tolerant to frost and suitable for chips.
Kufri Giriraj	1998	North Indian hills	Maturity medium; tubers white ovoid, eyes fleet, flesh white; resistant to late blight and immune to wart.
Kufri Anand	1999	North Indian plains	Maturity medium; tubers white ovoid-oblong, eyes fleet, flesh white; moderately resistant to late blight and immune to wart.
Kufri Kanchan	1999	North Bengal hills & Sikkim	Maturity medium; tubers red ovoid-oblong, eyes fleet, flesh cream; moderately resistant to late blight and immune to wart.
Kufri Arun	2005	North Indian plains	Maturity medium; tubers red ovoid, eyes medium deep, flesh cream; moderately resistant to late blight.
Kufri Pushkar	2005	North Indian plains	Maturity medium; tubers white round-ovoid, eyes medium deep, flesh light yellow; resistant to late blight and immune to wart.
Kufri Shailja	2005	North Indian hills	Maturity medium; tubers white, round-ovoid, eyes fleet, flesh white; moderately resistant to late blight.
Kufri Chipsona-3	2006	North Indian plains	Maturity medium; tubers white, round-ovoid, eyes fleet, flesh cream; resistant to late blight; suitable for chips and French fries.
Kufri Surya	2006	North Indian plains and plateau region	Maturity early; tubers yellow oblong, eyes fleet, flesh yellow; immune to wart; resistant to hopper burn and heat tolerant; suitable for early plating.
Kufri Himalini	2006	North Indian hills	Maturity medium; tubers white ovoid-oblong, eyes shallow, flesh cream; moderately resistant to late blight.
92-PT-27**	2007	Eastern plains	Maturity medium; tubers white-cream-yellow round-ovoid-oblong, eyes shallow to medium deep, flesh white-cream-yellow; field resistant to late blight.
Kufri Himsona	2008	North Indian hills	Maturity medium, tubers white round-ovoid, eyes fleet, flesh cream; resistant to late blight and suitable for chips.
Kufri Sadabahar	2008	Uttar Pradesh and adjoining areas	Maturity medium; tubers white oblong, eyes fleet, flesh white; resistant to late blight.
Kufri Girdhari	2008	North Indian hills	Maturity medium; tubers white ovoid-oblong, eyes fleet, flesh pale yellow; resistant to late blight.
Kufri Khyati	2008	North Indian plains	Maturity early; tubers white ovoid, eyes fleet, flesh cream; moderately resistant to late blight.
Kufri Frysona	2009	North Indian plains	Maturity medium; tubers white-cream long-oblong, shallow eyes, flesh white; resistant to late blight; suitable for French fries.
Kufri Neelima	2010	Nilgiri hills	Maturity medium; tubers white ovoid, eyes shallow, flesh white; highly resistant to cyst nematodes; resistant to late blight.
Kufri Garima	2012	Indo-Gangetic plains and plateau	Maturity medium; tubers light yellow ovoid, eyes shallow, flesh light yellow; resistant to late blight.
Kufri Gaurav	2012	North Indian plains	Maturity medium; tubers white-cream ovoid, eyes medium deep, flesh white-cream; nutrient use efficient variety.
Kufri Lalit	2013	Eastern plains	Maturity medium; tubers light red round, eyes medium deep, flesh light yellow; resistant to late blight.

Kufri Mohan	2015	Northern and Eastern plains	Maturity medium; tubers white-cream ovoid, eyes shallow, flesh white; moderately resistant to late blight.
Kufri Lima	2018	North Indian plains	Maturity medium-late; tubers white-cream ovoid, shallow eyes, cream flesh; extreme resistance to PVX and PVY and moderately resistant to root-knot nematode; resistant to hopper burn and heat tolerant; suitable for early plating.
Kufri Ganga	2018	North Indian plains	Maturity medium; tubers white-cream ovoid, shallow eyes, flesh cream; moderately resistant to late blight.
Kufri Neelkanth	2018	North Indian plains	Maturity medium; tubers purple ovoid, eyes shallow, flesh yellow; moderately resistant to late blight; specialty potato, rich in anti-oxidants with excellent flavour.
Kufri Sahyadri	2018	Nilgiri hills	Maturity medium; tubers light yellow ovoid, eyes shallow medium, flesh yellow; resistant to late blight and potato cyst nematode.
Kufri Karan	2018	Hills and Plateau region	Maturity late; tubers white-cream ovoid, eyes shallow, flesh white; resistant to late blight, APCLV, PVX, Y, S, A, M, PLRV; moderately resistant to PCN.
Kufri Manik	2020	Eastern plains	Maturity medium; tubers red round, eyes medium deep, flesh yellow; moderately resistant to late blight; possess anthocyanin and carotenoids
Kufri FryoM	2020	Northern and Central plains	Maturity medium; tubers white oblong, eyes shallow, flesh white; field resistance to late blight and potato virus Y; suitable for French fries
Kufri Chipsona 4	2020	Karnataka, West Bengal, Madhya Pradesh, and Gujarat	Maturity medium; tubers white-cream round, eyes shallow, flesh white; resistant to late blight; suitable for chips.
Kufri Sangam	2020	Northern and Central plains	Maturity medium, tubers white-cream ovoid, eyes shallow, flesh white; moderately resistant to late blight and excellent storability; Very good taste, aroma, mealy texture; suitable for table purposes and processing to chips & French fries.
Kufri Thar-1	2020	Orissa and Uttar Pradesh	Maturity medium, tubers white-cream round-oval, eyes shallows-medium, flesh cream; moderate resistance to late blight; very good storability; suitable for drought prone areas.
Kufri Thar-2	2020	Uttar Pradesh, Rajasthan, Haryana, and Chhatisgarh	Maturity medium, tubers light yellow ovoid, eyes shallow, flesh light yellow; good taste, typical potato flavor, mealy texture, very good keeping quality, long tuber dormancy; suitable for drought prone areas.
Kufri Thar-3	2020	Haryana, Uttar Pradesh and Chhatisgarh	Maturity medium; tubers white round-oval, eyes shallow, flesh cream. Slightly resistant to late blight; High water use efficiency.
Kufri Kiran	2021	North Indian plains and Plateau	Maturity early; tubers white-cream ovoid, eyes shallow, flesh cream; Tolerant to hopper/mite burn and high temperature; suitable for early plating.
Kufri Lohit#	2021	North Indian Plains (Central & eastern plains)	Maturity medium; tubers red, ovoid, eyes shallow, flesh cream, mealy texture; Field resistant to late blight
Kufri Uday#	2021	North Indian plains	Maturity early medium; tubers red, ovoid, eyes shallow, flesh yellow, mealy texture; Field resistant to late blight
Kufri Chipsona-5#	2022	North Indian plains	Maturity medium, tubers White-cream, ovoid, shallow, cream, mealy texture, Field resistant to late blight, suitable for chips
Kufri Bhaskar#	2022	Northern and Central plains	Maturity medium, tubers white-cream, ovoid, shallow, cream, mealy texture, tolerant to hopper and mite, suitable for early plating
Kufri Daksh#	2022	Central and Eastern plains	Maturity medium, tubers light yellow, ovoid, shallow, cream, mealy texture, water use efficient

*Not under seed production at present, **TPS population; #Notification awaited

Plains: Early (70-90 days), Medium (90-100 days), and Late (>100 days);

Hills: Early (100-110 days), Medium (110-120 days), and Late (>120 days)

11.2.2 Technologies in hand and future requests for sustaining potato production and utilisation

Arvind Jaiswal
CPRI, Shimla

11.2.3 Post-harvest Management and Storage of Potato

V.K. Singh
JISL, Jalgaon

Panel Discussion -3
Dynamics of change in pests & diseases of potato and strategic approaches in their management

11.3 Keynote Lecture

11.3.1 Diseases & their impact on potato production

Sanjeev Sharma
CPRI, Shimla, HP

11.3.2 Dynamics of pests & vector management in potato

Mohd Abbas
CITH, Srinagar, J&K

11.3.3 Progressing towards precision nutrient management in potato production

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With the growing concern of economic viability and environmental sustainability use of tools like GPS, GIS, UAV, models and DSS are likely to increase. It is likely that efficient and effectiveuseofinputs would lead to greatercropyieldand/orproductquality,withoutpollutingtheenvironment. The need-based nutrient application for potato and application of DSS in Indian agriculture have been initiated at many places. Use of UAV, with policy support from Govt. has started in big way, which will give further

boost to precision nutrient management. However,the cost effectiveness of precision nutrient managementhas not conclusively proven. In Indian scenario small landholdings appears to a major bottleneck to start with. Despite these challenges, with advancement in user friendly tools (apps, DSS, Models) and development of various types of cost effective sensors to capture minor variation of relevant abiotic and biotic parameters in soil and crop would lead to make this technology more usable and cost effective in coming days.

11.3.4 Revolutionize potato seed production through apical rooted cutting

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Potatoes, considers as the third most important food crop globally, is a major crop for both food security as well as income generation source in many tropical countries. Traditional seed potato production systems have been copied in many decades with minimal success. Prevalence of soil borne diseases and virus diseases build up over several generations of seed propagation coupled with prolonged seed storage at warm ambient temperatures are major constraints of potato. The high transportation cost is borne by the poor farmers who have to pay high seed prices as well. To make matters worse, the high price does not guarantee high quality, thus making it difficult for small and marginal farmers to invest such a large sum in seed purchases which accounts for nearly half of the total cost of production. Seed potato production through ARC technology is away to produce high quality potato seed, which would benefit the major potato production areas. ARC technology allows a seed producer to produce large quantities of seed potato from a relatively small piece of land. This is achieved through strict field hygiene and intensive control of pests and diseases. They have faster regeneration potential and are true to type. It is critical to maintain the mother plants in a juvenile simple rounded leaf state. Potato apical rooted cuttings (ARC) have been developed under tissue culture technique. Minituber production of ARC has been made both in substrate as well as in aeroponic systems. Mini tuber of ARC have resistant to biotic and abiotic stress. ARC revolution is bringing a great deal of excitement and promise of prosperity to remote and resource poor communities. The aim of climate resilient agricultural programme on Potato to disseminate the ARC technology amongst the farmers in Bihar for self sufficiency and up scaling the seed potato production.

11.3.5 Emerging scenario of potato seed production in India

B.P. Singh

CPRI, Shimla and Advisor, JSIL, Jalgaon

11.3.6 Technological changes in potato seed production

R.K. Singh
IIVR, Varanasi

11.3.7 Diagnostics in production of quality potato seed

Ravinder Kumar
CPRI, Shimla

11.3.8 Varietal development & requirement for meeting demand of different

Vinod Kumar
CPRI, Shimla

11.3.9 Technologies in Hand and future requests for sustaining potato production and utilisation

Arvind Jaiswal
CPRI, Shimla

11.3.10 Post-harvest management & storage of potato

V.K. Singh
JISL, Jalgaon

TECHNICAL SESSION-12

PRECISION SYSTEM IN POST HARVEST MANAGEMENT & FOOD SAFETY AND MARKETING

12.1 Keynote Lecture

12.1.1 Accelerating Indian horticulture through Innovations and value chain management

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Horticulture, which was a pleasantry before independence of the country has moved from the rural confine to commercialisation with the turn of the century, keeping a growth rate of 5.86 per cent with increasing demand, after 2000, referred to as **Golden Revolution**, and is projected to grow above 6 per cent, to achieve doubling of farmers' income, food and nutritional security, health care and environmental services. The achievements in horticulture till date is attributed to infrastructure for the research, investment of government with a mission mode approach and enabling policy initiatives. With the projected growth development is happening with innovative models of technology and its adoption, and the targeted production is achievable, but, not in usual mode of approach. The mission approach, which was envisaged to address all the issues in links of the chain from production to consumption in integrated manner has proved to be more successful in achieving the goals. However, there are concerns about competitiveness, which calls for efficiency in all the activities, starting from conceptualisation to production, post-harvest and cold chain management, transportation, marketing and brand management till it reaches to consumers. This calls for value chain development and management to benefit all the players in the chain and provide the produce to the consumer as per their requirement. Therefore, it is suggested that horticulture be declared as priority sector for investment and mission for Smart horticulture be launched with focus on value chain development and management on priority, which will go in long way as a prime mover of economic growth providing employment, food and nutrition security environmental services and above all availability of produce as per the needs both for domestic and export market.

12.1.2 Precision system in value addition of coconut for resilience

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Precision system in agriculture embraces multiple technological platforms to streamline, and improve the system efficiency of agricultural operations. Precision agriculture concept has been successfully

applied in monitoring the crop growth and development by investigating water, nutrient availability and other input supply features in many cropping systems. Precision system has immense scope in a plantation crop like coconut not only for input supply aspects but also in the field of value addition. Though a number of primary and secondary coconut based products with enormous nutritional potential has been developed and commercialized in India and elsewhere, application of precision system based production modules in the field of value addition of coconut and its supply chain is still in infancy. Precision system may be effective in the area of climbing, harvesting at right maturity, tapping, spoilage detection, grading, and quality evaluation. Identification of maturity and spoiled nuts before processing could lead to production of premium products. Sensors have been employed for detection of adulteration in coconut products such as virgin coconut oil, coconut sugar and desiccated coconut powder. This article discusses the potential of precision system in processing of coconut value added products and suggests way forward to embrace these technological advancements to harvest the benefits of overall efficiency, and sustainability etc.

12.1.3 A review on role of decomposers in agricultural waste management

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India produces more than 620 million tonnes agricultural waste annually. Agricultural wastes are generated from a number of agricultural activities and they include cultivation, livestock production and aquaculture. Agricultural waste contains 0.5% nitrogen, 0.2% phosphorus and 1.5% potassium as a source of plant nutrient. Most of the Indian farmers are practicing residue burning practices to clear the field in Rice-Wheat cropping system for timely sowing of the next crop. Crop residue burning releases harmful gases like CO_2, CH_4, N_2O, H_2S, O_3 and smog which causes air pollution and also create poor air quality index. It largely affects public life and disturbs soil physical, biological and chemical properties by destroying beneficial soil microorganism. Implementation of effective agricultural waste management can not only solve the air pollution problem but also provide better inputs to crop. The main objective of any waste management system is to maximize the economic benefit from the waste resource and maintain acceptable environmental standards. Management that puts into practice the principles of the four Rs of Reduce, Reuse, Recycle and Recover is the best first option. Agricultural waste residue management is decomposed by microbe such as bacteria, fungi, nematode etc. By successive catabolic reactions of microbes, all the organic matters are mineralized into soil essential constituents, which will be the most effective sources of macro- and micronutrients for the soil fertility. There are a variety of bio-decomposers such as bacteria, fungi, protozoa, etc. and they are capable to degrade cellulose by depolymerising cellulases which hydrolyze lignocelluloses. Most commonly known bio-decomposers are fungi which include Humicola, Trichoderma, Aspergillus, sclerotium, white-rot fungi, Trichoderma and Penicillium.The cellulose-producing bacteria are the potent bacterial cell lines in hydrolytical cleavage of agricultural residue in decomposition process which includes bacillus spp., pseudomonas, cellulomonas, etc. Researchers are working to improve the efficiency and storage of multiple types of microbes in an effective formulation product in one package which would have a high commercial value to sustainable agriculture.

12.1.4 Precision system in value chain management of fruit

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Fruits are considered as an important sector of agricultural production as they ensure food sufficiency, income for rural farms and have a major role in food security and nutrition for a wide segment of the population. India is one of the largest producers of some of the important fruits including bananas, guava and papaya but only 6-8 percent of the fruits are processed compared to China (23 percent), Indonesia (50 percent) and Brazil (70 percent). A considerable amount of fruits and vegetables produced in India is lost due to improper postharvest operations; as a result there is a considerable gap between the gross production and net availability. postharvest losses vary from an estimated 5 percent to more than 20 percent depending on the commodity due to postharvest decay by pathogens, and could be high as 50 percent in developing countries due to inadequate stirage, processing and transportation facilities respectively. Important sites where postharvest losses are noticed in India are: Farmer's field (15–20%), Packaging (15–20%), Transportation (30–40%) andMarketing (30–40%). In our country, horticultural value chains are often fragmented; lack investment; and fail to include vulnerable groups and are missing critical linkages of farms and markets. In the absence of simple and efficient value chain management, fruit growers are forced to sell their produce at a through away price which is uneconomical and does not even meet the cost of harvesting and transportation for marketing. The value chain consists of sequence of activities; process of value creation and delivery of products to the end customers. Therefore, simple and cost effective technologies were developed for post-harvest management, processing and value addition of fruits. Packing line for citrus fruits was developed at ICAR- Central Citrus Research Institute, Nagpur for mechanized handling of citrus fruits which include different operations like sorting, washing, waxing, drying, grading and packaging for enhanced shelf life and increase quality. Important interventions that reduce the post harvest losses and advance the supply chain management like establishment of pre-cooling facilities and short term storage facilities, viz. evaporative cooling, primary processing and packaging provision, transportation of fruits in refrigerated/evaporative cooled vans with the use of alternate energy sources and provision for low temperature and high humidity storage at the retail centres. Various high end value added products like ready-to-serve beverages, fizzy drinks, concentrates, pectin, peel oil, candy, nutri-jelly, etc. from citrus fruits were developed and commercialized for generating secondary source of income. With the help of precision system in the value chain management of fruits will ensure delivery of quality output to the consumer, for the small farmers to realize higher returns and at the same time increasing the availability and consumption of the produce during off season. Concerted efforts are required to improve the postharvest handling conditions, and thereby improve the socioeconomic status of the stakeholders in the fruits value chain.

12.1.5 Precision production technologies in spices and development of value chain

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India, known as the land of spices and Indian spices are the most sought-after globally given their exquisite aroma, texture, taste and medicinal value. Spices are high value and low volume commodities used in food, stimulant, preservative, flavour, colour, cosmetics, medicine and pharma. So every positive development in spices improves the quality of life world over.Spices form an integral part of socioeconomic in India which is the largest producer, consumer and exporter of spices in the world. With diverse agro-ecological conditions India is the home of a wide range of spice crops

Due to high value output per unit area spice commodities play a vital role in the export sector of agricultural goods. The potential of technology and innovation ecosystems in spice value chain and the trends in production and trade of spices are presented. Transforming new ideas into realty for profitability and sustainable viability of spice economy. Market intelligence and traceability systems need to be leveraged to gain critical control of spice markets across the globe. By creating an active flow of information and resources, from farm to fork can launch solutions to solve bottle necks faster and overcome the challenges posed by competing countries in global spice trade.

12.1.6 Fresh citrus fruit: Advances in precision handling and marketing

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Citrus fruits are grown in India since centuries and marketed directly by growers or traders through local and distant markets. Fruits lose moisture content in hot and dry environment and also decay due to fungal infection. India produced 14 million tonnes of citrus from 1.08 million hectare area in 2020-21 which is ten times more as compared to 1.25 million tonnes from 0.10 million hectare area in 1970s.In the past, fruits were harvested in bamboo baskets and were packed in wooden boxes with rice straw as cushioning material, transported in non-refrigerated rail wagons and trucks. More than 90% fruit were collected, sorted and packed in temporarily established centres in production areas during harvest season. No maturity standards were followed although fruits were packed and marketed as per size grades. The estimated post-harvest losses in mandarin, sweet orange and acid lime were 8–28%, 5-12% and 4-23%, respectively, depending on harvesting season during 1990s.In value chain, grower, pre-harvest contractor, commission agent/wholesaler and retailer are the important functionaries with major share of price paid by the consumer is taken by retailer (50%) followed by grower (34%), wholesaler (10%) and pre-harvest contractor (6%). In the past, very few grower's groups / producer organizations existed that could assert their share in prices. In the past, citrus fruits were cold-stored alongwith potatoes or apples leading to chilling and losses. During last 3-4 decades, scientific

developments, technological advancements coupled with financial support have transformed citrus fruit handling scenario. Now 80-85% Kinnow fruit is cleaned, wax coated and graded on packing-lines across north-west India, packed in printed cartons and transported to distant corners of the country. Mandarins are also now being handled on packing lines for sorting, wax coating and grading but at smaller scale (around 20-25%). From central India, most of the wax coated fruit is exported to Bangladesh. India exported 91,700 tonnes of citrus fruit in 2019 valued at Rs. 322 crore. Growers have started using refractometers to measure TSS in fruit. Refrigerated vans and warehouses dedicated to citrus fruit are being used. Many FPOs are formed during last 7-8 years and growers interests are being safeguarded in value-chain with their share in consumer price increasing up to 70%. Alternatives to fungicides such as antagonistic microbes, hot water, GRAS chemicals and edible coatings are emerging as acceptable and effective treatments in post-harvest handling. GAP at pre-harvest level, organic post-harvest treatments for protecting environment and fruit quality and safety management are the key issues for success in future citrus handling. Electronic vision-based graders using deep learning based AI models, near–Infra-red sensors, e-nose, biodegradable plastic films & smart packages, telematics and internet of things (IoT) for reefer containers, Block chain technology and non-destructive fruit quality analysis in orchard for crop maturity mapping using GPS are some of the advancements involving precision that define citrus fruit handling and marketing of present and future.

12.1.7 Supply chain for onion processing and improvement of farmers livelihood - A case study

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Being a globally important vegetable, onions are grown in 143 countries. India is the second largest producer of onions due to higher acreage under its cultivation. While conventional cultivation is filled with poor planting material, lack of adequate knowledge of the package of practices and constraints of borrowed finance. Hi-Tech cultivation removes these problems and provides several complementary avenues, which serve as incentive for cultivation. Ultimately benefiting the farmers and the company, both. This article narrated a case study out of las 23 years efforts done by Jain Farm Fresh Foods Ltd., a subsidiary of Jain Irrigation Systems Ltd., Jalgaon, the largest dehydrator of India from its two BRC (British Retail Consortium) by ISACert, The Netherlands ISO 14001-2015, ISO 45001-2018, ISO 50001-2018, OHSAS 18001-2007, Halal and Kosher certified dehydrating plants. The details of contract farming practiced at JFFL are given, reflecting the even-handed approach for sustainable benefits for both the stakeholders.

12.1.8 New molecules for increasing horticultural crop production

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A molecule is the compound that is made up of atoms that are held together by chemical bonds. Newly emerged synthetic compound are now used in the field of horticulture for enhancing production and productivity. It is estimated that it costs about 150-200 million to discover a new product, test it thoroughly for its action and its safety for the environment, and develop manufacturing techniques for its synthesis. It takes an average of 10 to 15 years to do this so it is small wonder that, worldwide, only about 12 chemicals are introduced each year. However, these chemicals are key to the efficient production of food. New molecules are preferred over old molecules as it is more promising and durable, environment friendly, required in less quantity and have less residual effect. New class of hormones, synthetic chemicals, nano particles etc has been playing important role in the horticultural field. These new molecules show effective biological response to avoid abiotic and biotic stress in the era of climate change. Need of new molecules is to increase productivity of crops, for improvement in efficiency of input use (cost saving), increase in crop intensity, tolerance against diseases etc. Brassinosteroid is a new class (sixth class) of plant hormone. It is extracted from rapeseed pollen. The BR is biosynthesised from campesterol. The yield of brassinosteroids from 230 kg of Brassica napus pollen was only 10 mg. Brassinosteroids helps in enhancing yield by 20-30 %. It also helps in avoiding stress. Fruit set increased by 0.5 to 2.5 times. It Regulate cell cycle and consequently cell division and hence increasing production.Jasmonates act as plant defense against environmental stress, which is derived from *Jasminum grandiflorum*. Reports depict the increase in anthocyanin content in fruits. Salicylic acid (SA) is synthesized from phenylalanine. It is a monohydroxybenzoic acid.

SA also induces specific changes in leaf anatomy and chloroplast structure. SA is involved in endogenous signaling, mediating in plant defense against pathogens. SA increases the shelf life, reduces disease incidence, alleviate chilling injury, act as an antioxidant and reduces browning in fruits and vegetables. Certain molecular compounds like Hexanal have been reported to extend the shelf life up to 52 days in mango. The hexanal sprayed mango trees remain green and fruits are shiny and retained in the trees itself for 2-3 weeks longer when other trees have already been harvested. New generation polyamine is low-molecular weight organic compound having two or more primary amino groups, linear polyamines perform essential functions in all living cells examples are putrescine, cadaverine, spermidine and spermine. Nano Molecules is new in the field of Nanotechnology. It is the branch of technology that deals with dimensions and tolerances of less than 100 nanometres, especially the manipulation of individual atoms and molecules. Nanoparticle based sensors/assays to detect contaminants in foods or monitor changes in packaging conditions or integrity. Nano sensors are used to detect the presence of gases, aromas, chemical contaminants and pathogens, detection of food adulterants, allergens or contamitants. Some Nanoparticles used in disease and pest management (Crop Protection) like Bioplymer nanoparticles,Metallic nanoparticles, Nano composites like Chitosan, Silver nanoparticles, Silica nanoparticles, Copper nanoparticles, Zinc nanoparticles, Chitosan Silver NP etc. The application of new generation molecules may improve the physiological efficiency of the crop growth and development mainly on delaying senescence, ethylene regulation, chlorophyll retention, pest and disease resistance, postharvest shelf life and quality in fruit crops. The time of application, crop stage, dosage, age of crop, plays an important role for effective utility of new molecules. However,

the availability, toxic effect and cost were the limiting factors of these molecules are still needed to be explored. New molecules are is an ecofriendly and improved approach for increasing horticultural crop production. The promotion of these molecules are must require to fetch the maximum income from the crop.

12.1.9 Approaches for secondary horticulture for profit optimization

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With the increase in demand for value-added goods and the region's diverse supply base, secondary horticulture has immense potential. The goal is to add value to goods through strengthening and expanding secondary horticulture and to meet market demands through manufacturing and rural industrialization. The objective is to increase the yield to maximum without compromising in the functionality, quality and nutrition of the compound through adoption of advanced technologies, equipments, and processes. The potential of secondary metabolites and bioprocessing can be harnessed to boost the economy, to achieve sustainable development, increase the socio-economic status and in environmental protection. The secondary horticulture is a highly complex area. It involves multiple factors like improved production technologies, modern infrastructure, capital investment, manpower availability and changes in Government regulations. Further, it also requires linkages between institutes and companies to bridge the gap and for successful dissemination of appropriate technologies and for creating marketing links. It executed and implemented successfully, it can generate 100's of billion dollars to the Indian economy and create millions of new jobs thereby transforming the life of the rural society which has so far not occurred in any significant way over the last 60 years.

12.2 Oral Presentation

12.2.1 Value addition avenues in tuberose

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Tuberose (*Agave amica* syn. *Polianthestuberosa* L.) is one of the commercial flower crops in India valued both for loose flower (directly or in the form of garlands, *venis*, etc mostly for worship, floral arrangements, etc) and cut flower (for vase decoration and making of floral bouquets). Extraction of concrete and essential oil is one of the value addition avenues which is highly lucrative. Tinting of cut spikes with food grade (preferably herbal dyes) dyes is another means of adding value in terms of fetching premium price in the domestic market. A study was conducted to evaluate the efficacy of food grade dyes in imparting colour to tuberose cut spikes without affecting the quality and vase lifein order to enhance the market price for these cut spikes. Ten different food dyes with floral preservatives (100 ppm S.S.A. and 2% Sucrose solution uniformly for all treatments) were tested on four tuberose

varieties (two each of single and double type). Single and double type varieties differed in their response to tinting in terms of colouration, quantity of dye uptake and vase life. Among single type, the highest quantity of dye uptake was recorded in Keshar (4.17 ml per day) and maximum vase life (5.5 days) was in Green dye in cv. Shringar whereas in double type, cv. Suvasini recorded highest dye uptake of Choco brown dye (4.7 ml per day) wheras vase life was found maximum (6.5 days) with Raspberry Red. The vase life increment of 0.50 days (Green) and 1.50 days (Yellow) were observed in case of cv. Shringar and cv. PhuleRajani, respectively. Similarly, an increment of 2.0 days (Raspberry Red) and 1.0 day (Pink) were observed in case of double type of varieties, cv. Suvasini and cv. PhuleRajat, respectively. For Tomato Red dye, both the quantity of uptake and vase life also remained least across all the varieties.

12.2.2 Effect of coating formulations and packaging perforation on bioactive compounds in litchi at cold storage

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In the present investigation, three-ingredient i.e á-Tocopherol, chitosan, and salicylic acid with their varied concentration and perforation percentage of packaging material were taken as independent variables for coating of litchi fruits to maintain bioactive compounds during storage. The litchi fruits subjected to 0.4% of á-Tocopherol, 2% of chitosan, 2 mM of salicylic acid, and 0.4% of perforation on packaging material had good retention of retention of bioactive compounds even at ambient temperature total phenolics in litchi 394.56 µg GAE/g fruit weight and total flavonoids 9.87 µg CE/g fruit weight along with radical scavenging activity of 35.75% (DPPH assay) at the end of 12th day of storage.

12.2.3 Sensors: smart technology for efficient management of ornamentals under protected conditions – a review

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Qualitative and quantitative characteristics in ornamental crops show significant variations due to subtle climatic changes. These climatic fluctuations affect various biotic and abiotic factors that can result in the occurrence of various plant diseases and disorders. To avoid such undesirable fluctuations, a precise and accurate monitoring system is essential under a protected cultivation system that can be

established with the help of key components known as sensors. Automation in the production of high-value floricultural crops can potentially optimize quality and yield with the help of various wireless sensing technologies that can record sensitive data such as moisture status, humidity, solar radiation, etc. Sensors provide real-time information about the plant growth status that can help a grower to regulate and optimize greenhouse climatic conditions as per the requirement of the crops. This review throws an insight upon various research works regarding the role of sensor technology in the floricultural sector under protected cultivation.

12.2.4 Valorization of 'Noni' (*Morinda Citrifolia* L.) fruit

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The experiment was conducted to study the effect of enzymatic treatments on the recovery of noni juice usingsixteen different enzyme treatments (Pectinase, cellulose and their combinations). The juice after extraction filtered, heat pasteurized and packed in glass bottles followed by processing (96±1°C) for 30 min. The juice was stored for 12 months to study the storage stability. Different treatments used for extraction of the 'Noni' fruit juice revealed that treatment of the crushed fruits with 0.1% Pectinase (T_3) for 3 hours gave maximum 50.52% juice recovery by pressing with better quality attributes and storage stability against manual pressing without enzyme (31.71%). The colour, body and overall acceptability of noni juice was observed to be significantly better when juice was extracted using 0.15% Pectinase at par with 0.10% Pectinase treatment (T_3) for 3 hours. The extracted juice remained shelf stable for 12 months at ambient temperature without any spoilage and contamination. The juice obtained form best treatment was also used for blending with mango pulp with 12 treatments for preparation of blended Noni mango nectar. The value addition of noni juice shows that blended Noni mango nectar can be prepared using 5% Noni fruit juice and 15% mango pulp followed by maintaining 16°Brix TSS and 0.3% acidity of the nectar remained shelf stable for the period of 6 months and found more acceptable on the basis of sensory scores and nutritional composition. The blending of noni juice (5%) with mango fruit pulp (15%) found to mask the effect of the pungent odour to great extent and so possess potential for preparation of 'Noni Mango Nectar'. This formulation of the nectar is liked extremely by the children which otherwise dislike the pure Noni juice. The blended nectar were found shelf stable during 6 months storage.

12.2.5 Waste valorization of banana peel into value added product

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Huge quantity of banana peel as a waste material is generated during the preparation of the banana puree in banana processing plant. The experiment has been carried out to optimize pre-treatment for

prevention of enzymatic browning in banana peel prior to blanching and preparation of paste to be used in banana based Sev. The results of the study revealed that dipping of banana peel in solution of 2% Salt (NaCl) along with 100 ppm ascorbic acid prevented enzymatic browning significantly and observed lowest enzymatic browning with OD (490 ppm) of 0.017. Further, the experiment for the preparation of Sev from banana peel using different formulations. The formulation of banana peel based sev possesses significant differences on the yield of the banana peel based Sev. The yield of the Sev significantly varied, with maximum yield in Sev prepared directly from the gram flour and minimum prepared from the formulation containing 50% banana peel. The fibre content among different formulations varies from 7.51 to 11.14%, with minimum fibre in Sev prepared directly from the gram flour and maximum prepared from the formulation containing 50% banana peel (F_6). Data depicted significant effect of formulations on the sensory qualities of the banana peel based Sev during three-month storage. Maximum sensory score were obtained by treatment F_1 (Sev prepared directly from the gram flour) while minimum by treatment containing 50% banana peel. The treatment F_1 was found statistically at par with the Sev prepared using 30% peel of banana. Banana peel based 'sev' with better nutritional and sensory attributes can be prepared by frying 'sev' in sunflower oil containing 150 ppm TBHQ followed by packing in aluminium laminated bag.

12.2.6 Waste valorization of mango peel and kernel into biscuits

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The present investigation was undertaken for utilization of mango peel and kernel for preparation of fibre rich biscuits "Nankhatai". India is the largest producer of mango in world with the share of 45.1 per cent. Beside this, India is also largest processor of mangoes with the share of 20 per cent. Processing of mango generated approximately 40-45 per cent of waste. Mango peel and kernel possessing very good nutritive value especially in term of dietary fibre can be utilized for preparation of the mango peel and kernel based biscuits. Biscuits are one of the most popular bakery product in the world used as snack food due to its ready to eat nature, affordable cost and availability in different taste. Mango peel and kernel based biscuits were prepared with different combination of mango peel powder 0%, 5%, 10% & 15% and mango kernel powder 0%, 5%, 7.5% & 10% along with other ingredients. Prepared biscuits were examine on sensory basis and results revealed that mango peel and kernel based biscuit 'Nankhatai" prepared by using 5% mango peel powder, 7.5% mango kernel powder and *maida* 87.5% (treatment T_7) and 5% mango peel powder, 10% mango kernel powder and *maida* 85% along with other ingredient (treatment T_8) possess higher sensory score on 9 point Hedonic scale as compare to other treatment combinations.

12.2.7 Approaches for enhancing the efficiency of farmer producer organizations to achieve enhanced income of the farmers

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Farmer Producers Organizations (FPO)is the group of farmers who come together to enhance their bargaining power in the market place for pooling their resources, knowledge and expertise together. These organizations aim to create sustainable livelihood for farmers by improving their agriculture practices reducing the cost and increasing productivity. The precision horticulture is a farming technique that uses technologies to optimize crop yield reduce waste and conserve resources. The precision horticulture involves use of technology like sensors, drones and GPS mapping to gather data real time data on soil and plant health, these data can then be used to make informed decisions about irrigation, fertilization, insect pests and disease management by adopting the precision horticulture techniques, FPOs can optimize their crop yield by providing real time data on soil and plant health, which will help in reducing the cost and improving the quality. Adoption of precision horticulture technique for FPO can have significant impact on the efficiency and can increase their profits and create a sustainable livelihood for the farmers. The precision horticulture technique shall also help the FPO to manage risk by providing real time data on plant health and weather conditions. It can also improve traceability by providing detailed information on crop, inputs and production methods. The precision horticulture can ultimately provide significant benefit to FPO by adopting techniques, which can create sustainable livelihood while producing high quality crops that meets the need of the market. Govt of India has facilitated the establishment of more than 10K FPO and under the CSS scheme there is target of promoting 10K more FPOs in India during next five years. These FPOs may be facilitated to precision horticulture while adopting precision horticulture to achieve the desired outcomes. The paper present it in details.

12.2.8 Evaluation of Rootstocks and crop load management on yield and juice quality in grapevine (*Vitis vinifera* L.) cv. Manjari Medika

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The present investigation on “Evaluation of rootstocks and crop load management on yield and juice quality in grapevine (*Vitis vinifera* L.) cv. Manjari Medika” was conducted in FCRD with three replications, having two factors *viz.* rootstocks (R_1 – Dogridge, R_2 – 110 Richter, R_3 – 1103 Paulsen and R_4 – 140 Ruggeri and crop loads (C_1 – 50 bunches, C_2 – 60 bunches, C_3 – 70 bunches and C_4 – 80 bunches/vine) at ICAR-National Research Centre for Grapes, Pune, Maharashtra during the year 2021-22. Vegetative growth parameters in Manjari Medika vines grafted on Dogridge (R_1) recorded the

highest shoot length (132.32 cm), shoot diameter (6.04 mm), internodal length (5.67 cm), pruned biomass (1.73 Kg) and leaf area (161.17cm^2). Vines with 50 bunches/vine crop load (C_1) had maximum, shoot length (127.95 cm), shoot diameter (6.38 mm), pruned biomass (1.36 Kg) and internodal length (5.35 cm). Amongst all the interactions, Manjari Medika grafted on Dogridge rootstock with 50 bunches/ vine crop load (R_1C_1) recorded the highest shoot length (144.50 cm), shoot diameter (7.17 mm) and internodal length (5.97 cm). Vines grafted on 110 R with 80 bunches/vine crop load (R_2C_4) had the maximum number of canes per vine (49.3).

The vines grafted on Dogridge with 50 bunches/vine crop load (R_1C_1) had significantly higher yield/ vine (42.21 kg), total yield (76.62 t/ha) and juice recovery percentage (78.56 %). Amongst all the interactions, Manjari Medika grafted on Dogridge with 50 bunches/vine crop load (R_1C_1) recorded the highest total sugar (21.20%), reducing sugar (18.48%), non-reducing sugar (2.72 %), total Anthocyanin (3.941 g/l), tannin (2.558 mg/g), carbohydrates (227.42 mg/g) and colour intensity (5.48 %).

12.2.9 Influence of priming on germination of khirni seedlings (*Manilkara hexandra* L.)

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The field trial was conducted at the Nursery and Research Farm, Department of Horticulture, College of Agriculture, Dhule during 2021-22, to study the influence of priming on germination of khirni seedlings (*Manilkara hexandra* L.).The experiment was laid out in a Complete Randomized Block Design with ten treatments*viz.*, T_1 (GA_3 @ 50ppm), T_2 (GA*ƒ* @ 75ppm), T_3 (GA_3 @ 100ppm), T_4 (GA_3 @ 200ppm), T_5 (NAA @ 100ppm), T_6 (KNO_3 @ 1%), T_7 (Cow urine @ 10%), T_8 (Cow urine 100%), T_9 (Cow dung slurry) and T_{10} Control (Distilled Water) with three replications.The treatment T_4(GA_3 @ 200ppm) resulted, the minimum days required for germination (30.33),however maximum number of seedlings germinate (42.33) at 15 days after sowingand germination percentage (84.67%) at 15 days after sowing observed in the treatment T_9 (cow dung slurry). Hence, it can be concluded that, the cow dung slurry were beneficial for increasing germination parametersas compared to other treatments under Khandesh region of Maharashtra.

TECHNICAL SESSION-13

OPEN SESSION FOR KNOWLEDGE SHARING THROUGH EFFECTIVE INTERACTION AMONG STAKEHOLDERS

TECHNICAL SESSION-14

KNOWLEDGE EMPOWERMENT OF FARMERS THROUGH QUIZ