National Conference on

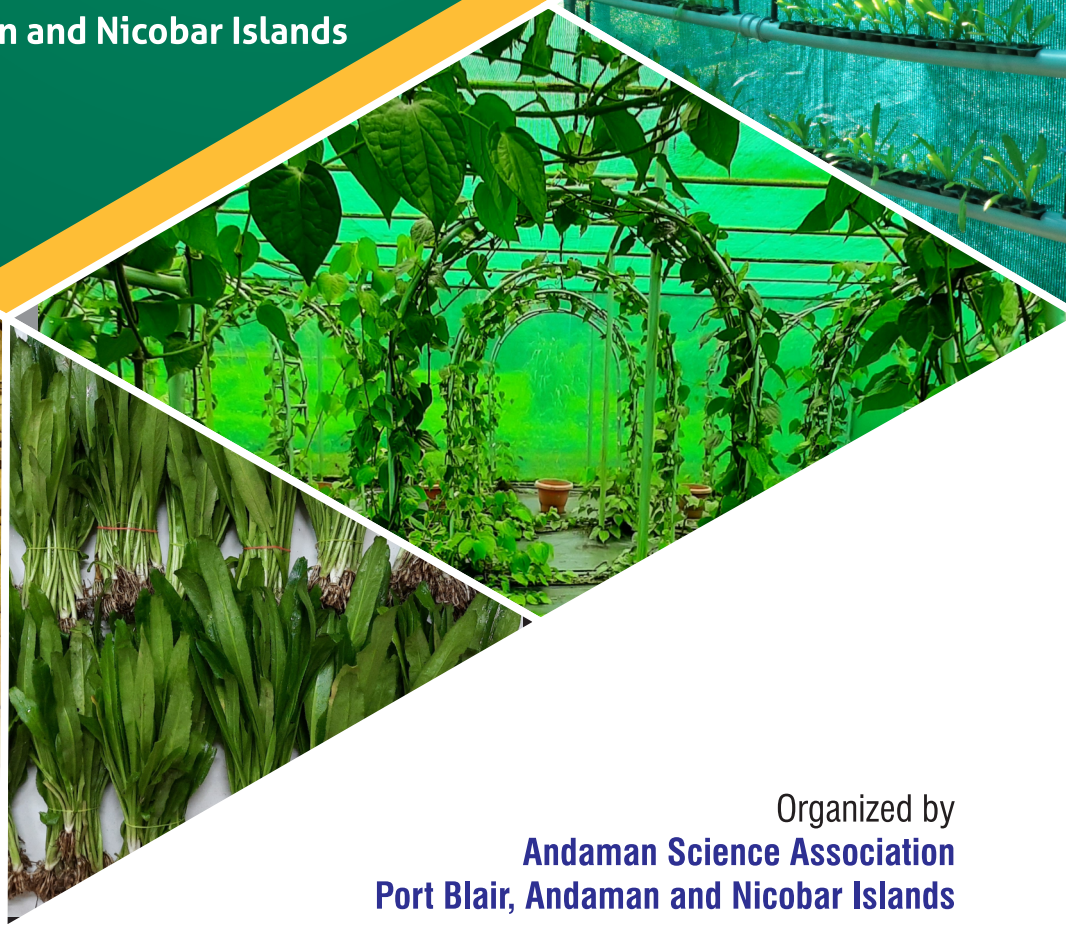
SPICES, AROMATIC AND MEDICINAL PLANTS FOR ECONOMIC PROSPERITY AND ECOLOGICAL SUSTAINABILITY (SAMPEPES-2023)

BOOK OF ABSTRACTS

October 5-6, 2023

Venue

ICAR-Central Island Agricultural Research Institute
Port Blair, Andaman and Nicobar Islands



Organized by

Andaman Science Association
Port Blair, Andaman and Nicobar Islands

In collaboration with

Directorate of Arecanut and Spices Development, Kozhikode, Kerala
ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands

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Editors

Ajit Arun Waman

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Preface

India is bestowed with diversified flora that has been traditionally utilized for various food, medicinal and other purposes. Spices have been an inseparable part of Indian cuisines, traditional healthcare as well as trade since ancient times. India, popularly known as the Land of Spices, has been a key player in the world spice market. In India, spices are grown in an area of about 4.53 million hectares with a production of 10.70 million tonnes. Spices contribute about Rs. 29,535 crores in national export, which amounts to 41% earnings among all the horticultural commodities and 9.67% of the agricultural commodities. India has a major share in the export of spices, contributing to 43% in terms of value and 48% in terms of volume in the international market. The importance of various medicinal and aromatic plants has been well documented in the traditional systems of medicines, which are gaining huge popularity among the global masses in recent times, especially after the COVID-19 emergence. This could be well understood from the fact that a large number of herbal products have flooded the markets and many commercial brands have been set up in the country. However, majority of the raw material is sourced from the natural stands thereby exerting pressure on the wild. Thus, there is an urgent need to strike a balance between the economic development and ecological security. The present conference is a timely effort in having scientific deliberations to address the emerging issues in the production system and utilization patterns of these crops. The National Conference on Spices, Aromatic and Medicinal Plants for Economic Prosperity and Ecological Sustainability-2023 has received overwhelming response with participation from 22 states and union territories of the country. The hybrid mode has widened the avenues for knowledge dissemination among the stakeholders from different parts of the country. The present abstract book is a compilation of abstracts from distinguished keynote addressee, invited speakers and oral and poster presentations from the highly qualified researchers and academicians of our country. I am hopeful that this compilation would be useful for the stakeholders dealing with various aspects of spices, aromatic and medicinal plants.

Dr. E.B. Chakurkar

CONTENTS

Keynote Address

Dr. M. Madhava Naidu

Dr. M. Madhava Naidu, Retd. Head and Chief Scientist, Plantation Products, Spices and Flavour Technology (PPSFT) Department, CSIR-Central Food Technological Research Institute, Mysore studied M.Sc. Botany from Gulbarga University, Gulbarga and subsequently obtained Doctoral degree from the same university. He worked in advanced areas of Coffee-biotechnology at Central Coffee Research Institute, Balehonnur, Karnataka (1990-1999) before joining CSIR. His contributions to Science & Technology as evidenced from the R&D outcome resulted in more than 80 research and review articles, one book and six book chapters. In addition, 28 PDRU know-how process were developed by him and many of them have been transferred to small and medium scale industries. He has successfully completed more than 20 projects. To his credit 20 patents were already granted and another 4 more have been filed. Five students worked under his guidance were awarded Ph.D. degree and at present one more are working under AcSIR programme. He has also guided more than 60 M.Sc./ B. Tech./ M. Tech. students for their dissertation works. Projects proposed by him in order to understand the need of the food industry and conceptualization of new ideas, have resulted in grant of sponsored and consultancy projects for the PPSFT Department with special reference to the states of Andhra Pradesh, Telangana and Maharashtra. He is Member for ISO, BIS and Codex since 2014 in the area of Spices and Plantation Crops. He was convener for FAD 9 for review and revision of Indian Standards on Spice oleoresin. He is a recipient of prestigious DBT National Associateship Award (1993-94), Best Scientist Award (2010-11), Best Technology Transferred Award (2017), Highest ECF Generated Award (2018) from CSIR-CFTRI. He was bestowed with Fellow of Society for Plantation Crops (2017) from Indian Society for Plantation Crops (ISPC), ICAR-CPCRI, Kerala and Life Time Achievement Award (2019) from International Society for Horticulture, Agriculture and Plant Sciences, New Delhi. He is serving as faculty member of the post graduate programs in CSIR- CFTRI and he is also member of many professional bodies and he was in the Editorial Board of the Journal of Food Science and Technology (Springer) during 2015-17. He was nominated/ appointed by Ministry of Commerce, Govt. of India as Board Member for Coffee Board (March 2019 to April 2022). Also, he has been nominated/appointed by Ministry of Commerce, Govt. of India as Board Member for Spices Board (March 2023 to April 2026). He demonstrated and has the competence of potential leadership qualities in coordinating interdisciplinary research with various other departments in CSIR-CFTRI as well as proven record of expertise in the activities he has undertaken. He has delivered more than 60 lead talks at various national and international events.

Keynote Address

Technological Interventions: Value Addition of Herbs and Spices for Economic Prosperity

M. Madhava Naidu*

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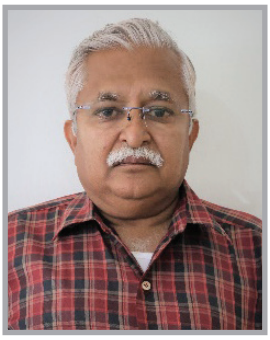
Herbs and spices are aromatic and important flavourant to food applications. The word 'spice' is synonymous with anything that creates a piquant effect. Since ancient times, India has been the house of many important spices like turmeric, pepper, ginger, garlic, cardamom and chilli. India, with its favourable climatic conditions for growing spices, is the largest producer and consumer of spices. During 2021-22 India exported 12 lakh tonnes of spices and spice products, which were worth US $ 4100 million. Though India is a major producer of herbs and spices, not much attention has been paid to the improvement in their quality and their products. The importing countries are very particular about standards relating to safety and hygienic quality in the spices including the absence of foreign material. In international trade, more emphasis is being laid to microbial load, pesticide residues and heavy metal contamination. Given the increasing interest in the beneficial role of nutraceuticals in health, in-depth study of the bioactive constitutents of herbs and spices assumes significant prominence. Dehydrated spices with their bioactive constituents have been shown to have good consumer acceptance as well as shelf life and could serve as a valuable food additive to enhance human nutrition. Spices are export oriented commodities earning considerable amount of foreign exchange. During primary processing of spices, due to inadequate drying, improper handling of spices and storage practices, the crops become susceptible to fungal attacks. Recent report by FDA suggested that Indian spices are heavily contaminated with *Salmonella* and it is second most contaminated spices imported to USA. There is a need to achieve complete sterilization of spices free from *Salmonella* contamination and also from total bacterial contamination. Digitalisation is already a part of our normal daily lives and it is also becoming increasingly important in the sourcing of spices and herbs. New trends include the use of sensors, digital tools and online activities to make the whole supply chain more transparent and sustainable. In this direction, CSIR-CFTRI conducts basic research on primary and secondary processing, chemistry, development of new spice based processes, products and spice processing machinery. Therefore, the purpose of this keynote address is to provide a comprehensive review on the recent research/ technologies on spice processing, including value addition and their nutraceutical applications.

Keywords: contamination, foreign exchange, nutraceutical, quality

Theme 1: Genetic Resources, Conservation and Crop Improvement in Spices and MAPs

Invited Talk



Dr. Vijay Mahajan

Born on March 22, 1964 at Ainpur, Maharashtra, Dr. Vijay Mahajan obtained his B.Sc.(Ag) from JNKVV, Indore, M.Sc. (Hort.) and Ph.D. (Hort.) degrees with specialization in Vegetable Science from Indian Agricultural Research Institute, New Delhi. Further he did Post Graduate Diploma in Technology Management in Agriculture in 2015 from ICAR-NAARM, Hyderabad. Dr. Mahajan started his carrier as an Assistant Professor at Indira Gandhi Krishi Vishvavidyalaya and later was selected in ICAR as Senior Scientist at National Research Centre for Onion and Garlic in 2000. He is looking after All India Network Research project on Onion and Garlic as Nodal Officer since inception *i.e.* 2009. He was Acting Director of ICAR-DOGR, Pune, Maharashtra from November, 2016 to April, 2017 and June, 2022 to February, 2023, wherein he joined as the Director since June 22, 2023. He has 27 years of experience in research, teaching and extension at University and ICAR. During his career, he developed 10 onion and 2 garlic varieties at national level notified by CVRC. He also developed first kharif white onion variety Bhima Shubhra in India for which he was designated as the '*King of Onion*' at the 'Krishi Vasant' held at Nagpur (Feb. 9-13, 2014) by Honourable Ex-President of India Late Shri Pranab Mukharjee. He introduced onion cultivation in the tribal belt of Nandurbar. Being Nodal officer, DUS and Member of the Task Force, he formulated DUS guidelines for Onion and Garlic. Dr. Mahajan has worked/ is working as a member of different committees of various ICAR institutes *viz*. NRCOG, DOGR, NRCG, DFR, ATARI, NIASM and CPRI. Dr. Mahajan guided 12 students, evaluated M.Sc. and Ph.D. thesis of various universities, written more than 90 research papers in national and international journals, presented more than 175 papers in national and international symposia, published more than 200 popular articles, 32 book chapters, 30 booklets/ folders and delivered more than 225 lectures at various forums apart from 45 radio and TV talks. He has international Exposure on onion at USA (USDA-ARS), Vegetable Crop Research Unit, Department of Horticulture, University of Wisconsin, Madison, WI, USA, NIAB, Cambridge, UK and Chaired Crop Improvement Session in International Symposium on Edible Alliums at Turkey. He organized two national Symposia and one International Symposium on edible Alliums. Dr. Mahajan is recipient CSIR Associateship, Young Scientist Award from MP Council of Science and Technology, Bhopal (1996), Certificate of Merit at IGKV, Raipur (1996), Fellow of Indian Society of Vegetable Sciences (2018), Fellow of Indian Academy of Horticultural Science (2020), Fellow of Confederation of Horticulture Associations of India (2021) and Fellow of the International Society of Noni Science (2022). He has been felicitated by Indian Society of Allium (2016) for significant contribution in onion and garlic research in India, received NHRDF Award (2017) for outstanding contribution in onion and garlic research, International Scientist Award- Lifetime Achievement (2021) from VDGOOD Professional Association and CHAI Appreciation Award (2022).

IT/1.01

Onion (*Allium cepa* L.) Breeding for Quality Traits and Export

Vijay Mahajan*, Amar Jeet Gupta, Ashwini Benke, S.J. Gawande, Ram Dutrta, A. Thangasamy, Pranjali Gedam, Yogesh Khade & Rajiv Kale

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In India, onion and garlic are integral part of daily diet in every household. Onion is grown under three crop seasons *i.e. kharif,* late *kharif* and *rabi.* Main crop is in *rabi* which covers about 50% of production whereas, 20% is from *kharif* and 30% from late *kharif.* Maharashtra, Karnataka, Gujarat, Bihar, Madhya Pradesh, Rajasthan, Andhra Pradesh and Tamil Nadu are the main onion growing states in India. In general, barring North Eastern states and Kerala, all other states grow onion. Country's 26% area and 29% production alone come from Maharashtra. About 90% export of onion is from Maharashtra. India is the largest producer of onion. During 2019-20, total area under onion was over 14.31 lakh hectares with a total production of 26 lakh tons and productivity 18.23 t/ha (DAC&FW, report 2020). Introduction, mass selection, selfing and massing, inbreeding, hybridization and heterosis breeding have been used for improvement of onion. Major breeding objectives are 1. High yield, 2. Superior bulb quality traits (size, shape, colour, pungency, firmness and dormancy), high total soluble solids content (important for dehydration industry), skin retention and high dry matter, 3. Resistance to diseases (purple blotch, basal rot, *Stemphyllium* blight, anthracnose, pink root rot and bacterial rot), 4. Resistance to insect pests, mainly thrips, 5. Resistance to abiotic stresses (moisture stress, high temperature, salinity and alkalinity), 6. Development of high yielding varieties capable of producing good seed yield, 7. Development of disease resistant F_1 hybrids with superior quality bulbs, 8. Development of varieties suitable for export market. Development of varieties have focus on bulb should be attractive, uniform in size, shape, colour and time of maturity with flavour (pungency), high dry matter and long storage life. Additional desirable features are intact and attractive skins, thick leaf scales (rings), single centred bulb, thin neck and resistant to early bolting, diseases and pests. Various breeding methods were followed in onion improvement for quality production and export and most adopted method is mass selection, recurrent selection, pedigree selection, single bulb selection followed by mass selection, heterosis breeding, mutation breeding, family selection, pedigree selection, mass selection and intra-varietal recurrent hybridization, backcross for transfer of desirable characters.

There is great role of developed varieties recommended for different climatic zones which resulted in increase in production and productivity of onion in India. Onion is biennial crop and takes almost 12 to 14 years to purify or develop a new variety which is cumbersome. Varieties in onion were developed by different SAUs and ICAR institutes and tested under coordinated/ network project for release at national level for different agro-climatic conditions. Till now about 70 onion varieties including 2 F_1 hybrids and 6 multiplier type have been developed and released from public sectors for different colours (Light red, dark red, white and yellow), types (Common, rose and multiplier type), locations (short and long day) and seasons (Kharif, late Kharif and rabi) at state or national level. Out of which more than 33 onion varieties have been released through AICVIP/ AINRPOG including 10 onion varieties from ICAR-DOGR.

Recently due to late monsoon or irregularities of rain in Kharif season there has been shift in planting from Kharif to late Kharif. Some of the varieties like Bhima Shakti and Bhima Shubra developed by ICAR-

DOGR and Phule Samarth developed by MPKV, Rahuri are recommended for late kharif season. Still there is need to intensify research work in India for different location for late kharif season for early arrivals in market. Climate change due to global warming and pollution has become major concern to the crop scientists and how to address this and prepare for is an important issue. Work on development of photo and thermo insensitive varieties is undertaken at ICAR-Directorate of Onion and Garlic Research, Rajgurunagar to tackle the changing climatic situations. Some of the germplasm were found promising and can be grown in all the three seasons *viz*., *Kharif*, late *Kharif* and Rabi seasons is being exploited for such situations. Varieties like Bhima Super, Bhima Red, Bhima Raj and Bhima Shweta gives photo and thermo neutral response have wider adaptability and can be cultivated in all the three seasons under short day plains as well as under long day hills conditions. ICAR-DOGR identified and registered water as well as drought tolerant lines in onion and standardized the method also. Underutilized Alliums are also being exploited for consumption and in breeding programme and identified three lines being popularized through value chain. Further identification of tolerant genotypes against pests and diseases and storage is in progress. Hence, there is need to develop Varieties for different seasons, biotic and abiotic stress, processing, green foliage, export quality, mechanized farming for large as well as small farmers, better keeping quality, organic cultivation, set planting, face climate change, early maturity, tolerant to bolting and finally according to consumers demand of our country and export demand of different countries.

Dr. K. Pradheep

Joined the ICAR service in 2003, Dr K Pradheep, Principal Scientist & OIC at ICAR-National Bureau of Plant Genetic Resources, Regional Station, Thrissur is working particularly on the activities pertaining to germplasm collection, characterization, conservation, and taxonomic and systematic studies. He has undertaken 55 exploration trips in remote, tribal, land-locked, and international border areas and covered >28 states of the country, with an emphasis on Andaman and Nicobar Islands, Jammu and Kashmir, North East Hill region, for a variety of crop groups including temperate fruits, vegetables, spices, ornamentals, medicinal plants and forages. These efforts have culminated in the collection of 4,924 accessions including several unique germplasm and >100 crop wild relatives (CWR) previously not collected. Nine trips were exclusively conducted in Protected Areas and four for trait-specific germplasm collection. His specific research areas include systematic study of native taxa such as *Sesamum*, *Solanum*, *Trichosanthes*, *Allium*, *Luffa* and leafy amaranth developing field keys their taxonomic identification, germplasm collection of CWR and cucurbitaceous vegetables, and build-up of correctly-identified herbarium vouchers (1,700 specimens) for NHCP. He has described four new taxa, reported 9 CWR new to the country, solved taxonomic ambiguity that prevailed in 8 crops/ economic species and was involved with the development of two crop varieties and registration of four germplasm. His book “Wild Relatives of Cultivated Plants in India” was published by ICAR in the year 2014, which contains details of CWR of >2,000 cultivated plants in India, and thereafter prioritized the CWR taxa for collection and conservation.

IT/1.02

Crop Wild Relatives of Spices, Medicinal and Aromatic Plants: What Can they Offer?

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In most of the crops, the available germplasm base within the crop has been found insufficient to meet the ever-growing needs of breeders. Therefore, the search for new genes and their sources is extremely important for current as well as future crop improvement, and one such source is crop relatives. Wild forms/ populations and/ or weedy populations of crops, wild progenitors and wild taxa closely related to crop plants, all constitute Crop Wild Relatives (CWR). An integrated approach involving morphology, cytogenetics and molecular systematics supplemented with allied evidence (graft compatibility, palynology, chemotaxonomy, micromorphology *etc*.) would help establish the level of relatedness of wild species with the crop. There are roughly 133 species of spice, medicinal and aromatic value cultivated in this country. An attempt to prioritize the Indian CWR of important crops based on the overall closeness of wild taxa with the crop and their usefulness in crop breeding resulted in the prioritization of 82 CWR taxa in 19 spice crops and 103 in 24 Medicinal and Aromatic Plants (MAPs). Thirty-eight cultivated species (out of 43) have their wild forms/ weedy populations distributed in India. Only a handful of CWR taxa have been known for their potential use in crop improvement and rootstock value, although many more species might possess much-demanded traits.

For crops of Indian origin or diversity such as black pepper, cinnamon, ginger and turmeric, close relatives do occur in this country. There is some success in the utilization of relatives of black pepper, vanilla and Garcinia crops available. Although many wild species of *Zingiber* and *Curcuma* are available in India, a general lack of biosystematic studies to unearth CWR species of ginger and turmeric, respectively and limited works in screening for useful traits among wild species, and sterility or absence of seed-setting in these crops limit the transfer of useful traits from CWR. In the case of seed spices, though most are of exotic origin (especially in the Mediterranean and West Asia), mention may be made of the wild forms/ weedy populations of caraway, *ajwain*, celery, fennel and black caraway occurring in parts of Himalaya. In the case of MAPs, ample potential does exist in utilizing all wild species belonging to the genera *Cymbopogon*, *Mentha* and *Ocimum* as they are relatively closer to the crops and reports of interspecific hybridization are available.

Some reasons behind poor utilization of CWR taxa would be (1) available variability within the crop itself not being fully utilized, (2) long gestation period, (3) lack of sufficient manpower to carry out basic works (unlike field crops), (4) unavailability of taxonomically-authentic CWR for study, and so on. In the context of increasing pressure on wild species population, the negative impact of climate change and meagre *ex-situ* germplasm collections, intensifying the activities related to survey, exploration, collection and conservation of the germplasm of wild relatives and distant hybridization and rootstock compatibility studies needs no emphasis. Specific emphasis may be given to addressing problems of taxonomic misidentification and synonymy, assembling representative germplasm of all the prioritized taxa, screening wild germplasm for stress tolerance at the field as well as artificial conditions, evaluating them for yield and quality-related parameters and crossability studies. Continuous focus and sustained interest till the transfer of trait from CWR to crop is essential keeping in view the underlying long gestation period. Strengthening linkage at the national and international levels with partner institutes, NAGS, NGOs *etc*. would help in the faster realization of CWR utilization.

Theme 1: Genetic Resources, Conservation and Crop Improvement in Spices and MAPs

Oral Presentations

O/1.01

Akola Smruti: Regular Bearer Variety of Tamarind Suitable for Rainfed Areas

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Tamarind (*Tamarindus indica* L.) is an important dryland fruit cum spice crop. Tamarind is one of the most suitable crops for rainfed, watershed and wasteland. Though, every part of the tamarind is useful, the fruit is the most important part. It is one of the most acidic fruit species and contents rather uncommon plant acid *i.e.* tartaric acid. The fruit pulp is an important product, which is a common article of trade in India. Tamarind is widely used as a souring agent in various Indian food preparations. Tamarind pulp can be used in the preparation of jam, jelly, pulp and beverages. In South American countries, it is often relished in the form of refreshing drinks. In Vidarbha region of Maharashtra, each and every village has tamarind trees, which show considerable variations. Tamarind crop has irregular/ alternate type of bearing habit. Yield potential of this crop is also quite good but, there is no any variety available in the Vidarbha for commercial cultivation of this crop with regular bearing habit. With this background, surveys were made and 39 genotypes were identified for further screening. During 2002-2006, very erratic and very less rainfall was received in the Akola area, due to which most of the established fruit trees started drying due to scarcity of the water and very negligible fruiting were seen in different fruit crops. However, good fruiting was observed on limited trees of tamarind. Among the bearing trees of tamarind, AKT-10 was found to be superior in bearing. It indicated that, this type may be an asset for future for drought prone and dryland areas of Vidarbha. Considering the bearing habits of different genotypes, AKT-10 was found regular bearer and also produced maximum yield per plant (1.68 q). This high yielding, regular bearer genotype with good quality was christened as Akola Smruti and was recommended for cultivation in the rainfed areas of Vidarbha region.

Keywords: Acidulant, dryland, genetic improvement, *Tamarindus indica*

O/1.02

Performance of Elite Genotypes of Fennel (*Foeniculum vulgare* Mill) under Akola, Maharashtra Conditions

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A field experiment was conducted under Akola, Maharashtra condition with an objective to study the performance of different fennel genotypes for plant growth, seed yield, quality parameters. The experiment was laid in Randomized Block Design with fourteen treatments and three replications. The treatments included twelve genotypes and two check varieties. Results revealed that, for growth parameters, the genotype T1 (IC-530571) was found to be significantly superior as the highest plant heights (63.93, 134.23 and 170.80 cm, respectively at 60, 90 and 120 days after sowing, DAS) and number of primary branches per plant (5.60, 6.67 and 6.90, respectively at 60, 90 and 120 DAS) were reported in it. For flowering and fruiting parameters, the genotype T9 (IC-589328) was found to be significantly earlier in terms of first flowering (66.33 DAS), 50% flowering (90.33 DAS), 75% maturity (101.33 DAS) and 100% maturity (124.67 DAS). With regard to quality parameters, genotype T8 (IC-598499) was found to be significantly superior in terms

of test weight (5.87 g); whereas, the genotype T9 (IC-589328) was found to be significantly superior with respect to weight of seeds per umbel (1.33 g). For yield and yield contributing parameters, genotype T6 (IC-598510) was found to be significantly superior with highest number of seeds per umbel (276.86); whereas, genotype T1 (IC-530571) was found to be significantly superior for number of umbels per plant (17.79), number of umbellates per umbel (24.03), seed yield per plant (20.60 g), seed yield per plot (927 g) and seed yield per hectare (10.30 q/ha).

Keywords: morphology, seed spice, quality, yield

O/1.03

Conservation and Characterization of *Garcinia cowa*: a Medicinally Important Species of Tripura

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Northeastern region of India is one of the biodiversity hotspots, which harbours numerous medicinally important plant genetic resources. Tripura is one of the northeastern states, whose agro-climatic conditions (humid-subtropical warm climate), fertile soils and abundant rainfall favours the cultivation of various minor fruits. *Garcinia cowa* or Cowa Mangosteen is one of the medicinally important minor fruits generally found in the wild and semi – wild conditions with occasional occurrences in the backyards of Tripura. This fruit is reported to be used by the local people/ traditional healers as fresh fruits as well as for medicinal purposes. However, so far no systematic studies have been carried out about crop improvement, propagation and production technology of cowa mangosteen. In order to document the existing diversity, conserve the genetic resources and explore the potential of this species for inclusion in the existing farming system for crop diversification, the studies were taken up. In this study, we explored West Tripura, Khowai, South Tripura and Gomati districts of Tripura during 2020 - 2022 to identify elite promising genotypes. The collected germplasm was evaluated for the morphological and physio-chemical characters, and storage studies were conducted following standard protocols. Among the genotypes evaluated, variability was noticed for fruit length (18.1 ± 1.10 to 46.0 ± 1.10 mm), fruit diameter (28.5 ± 0.30 to 36.0 ± 0.38 mm), fruit weight (15.5 ± 0.81 to 45.0 ± 0.90 g), seed weight (3.5 ± 0.56 to 24.0 ± 0.88 g) and total soluble solids content (10.9 ± 0.16 to 16.5 ± 0.22 ºBrix). Three promising elite genotypes *viz*. TRC/Kok/WT-1/20, TRC/ Kok/ ST-2/21 and TRC/ Kok/ K – 3/21 were identified. For conservation of the species, regeneration protocol was also standardized. Our study has opened up the prospects for including this lesser studied genetic resource as a component for diversification in the existing farming system. Its domestication and popularization among the small and marginal farmers would help in achieving their nutritional security and livelihood improvement.

Keywords: Minor fruit, cowa mangosteen, conservation, biodiversity, Tripura

O/1.04

Mutagenic Studies in Black Turmeric (*Curcuma caesia* Roxb.) – An Underexploited Medicinal Plant

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Black turmeric (*Curcuma caesia* Roxb.) is a highly valuable medicinal plant of Zingiberaceae family with bluish-black rhizome. It is an underexploited species, which has high medicinal value especially in the treatment of piles, bronchitis, asthma, impotency, cancer, epilepsy, fever *etc*. Since it is a vegetatively propagated crop, genetic improvement through other methods like hybridization is difficult. So, mutation breeding is an important method for creation of genetic variability. In this study, mutagenic treatment was done in black turmeric using gamma rays (10, 15, 20, 25, 30 and 35 Gy), ethyl methane sulphonate (1.00, 1.25 and 1.50 %) and colchicine (0.1, 0.2 and 0.3 %), with the objective to create variability and identify the desirable mutants. The experiment was laid out in RCBD design with thirteen treatments and two replications. The mutant population was evaluated for growth, yield and quality parameters and was compared with untreated control. Among the different treatments, T13 (control) recorded maximum plant height (71.80cm), pseudostem girth (9.32cm), number of leaves (24.20), rhizome yield per plant (130.03g), number of primary rhizomes (4.59), number of secondary rhizomes (11.64), rhizome length (11.06 cm), rhizome width (14.41cm), weight of mother rhizome (30.75 g), oleoresin content (6.8 %), crude fibre (4.69 %), curcumin (0.008 %) and essential oil (0.36 %) content. The mutagenic treatment resulted in reduction of growth, yield and changes in chemical composition of essential oil of black turmeric. Both chlorophyll mutants (albino and xantha) and morphological mutants (dwarf plant and split leaves) were observed. Colchicine treatment resulted in an increase in chromosome number.

Keywords: medicinal plant, EMS, Gamma, rhizomatous species

O/1.05

Air Layering as a Rapid Method for Multiplication of an RET Medicinal Plant- Guggul (*Commiphora wightii* Arnott.)

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Guggul (*Commiphora wightii* Arnott.) is a small shrub belonging to the family Burseraceae. Since time immemorial, the plant has been exploited by indiscriminate gum-tapping methods. The species has been included in the Red Data Book of IUCN and needs to be conserved on priority basis. Author's Institute has the largest collection of 225 germplasm maintained in the field gene bank. However, maintaining field gene bank has become challenging due to involvement of high maintenance cost. Establishing a small population gene bank in a small area represents all the germplasm with true-to-type plants can save huge maintenance costs. Guggul can be propagated by sexual and asexual means. The semi-hardwood stem cuttings required more time for rooting (65 to 70 days) and the field establishment of plants was low (*ca*. 50%). Likewise, there exists a lot of contradiction with respect to the most appropriate and viable method of guggul propagation for multiplication and conservation point of view. Hence, present study on air layering was initiated to

determine the suitable and alternate method for guggul propagation. During the mid-June (rainy season), shoots were air layered by girdling the pencil-sized shoots. These ringed and girdled portions were covered with sterilized coco peat and sphagnum moss, which was soaked overnight in normal water. Then, it was wrapped with a transparent polyethylene sheet and made air-tight by tying both ends of the polyethylene sheet with jute threads. The rooting was initiated in the air layer after 21 days and full rooting was observed after 30 days compared to semi-hard wood cuttings for full rooting (65 to 70 days). Finally, all the rooted layers were drawn off from their respective plants after 35 days of layering by cutting them just below the girdled portion. All air layers were established in nursery bags (20 ×15 cm). Thus, air layering could be an alternative and efficient method to establish the true-to-type gene bank of guggul in a short span.

Keywords: Gene Bank, Germplasm, marcottage, propagation

O/1.06

Conservation Studies in Threatened Medicinal and Spice Plants of Kumaun Region of Uttarakhand, India

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Out of the list of many endangered and threatened medicinal or spice plants, this study focuses on the conservation of two very important medicinal plants *i.e.* Maiden Hair (*Ginkgo biloba* L.) and Glory Lily (*Gloriosa superba* L.) along with ginger, which is not threatened but local germplasm requires conservation. Maiden Hair is the only member of family Ginkgoaceae and referred as a living fossil. Though the natural habitat of *G. biloba* is in China, Japan and Korea but a very few old trees < 100 years old have been reported in Kumaon region of Uttarakhand. *G. biloba* needs to be conserved for having very special characteristics of sturdiness, longevity and medicinal properties. Macropropagation of this important plant is in progress at author's institute. Observations on growth parameters and other characteristics were recorded. Glory lily is a tropical plant with many medicinal properties. This plant contains alkaloids mainly colchicines and gloriosine, which are useful in the treatment of gout, snake bites and scorpion stings. Commonly, it is propagated through underground V-shaped rhizomes but plant population is very scarce in its natural habitat. Low seed set and poor germination of seeds is another issue in its faster propagation. So achieving the standard protocol for efficient seed germination under *in vitro* conditions is in progress. As a spice, ginger is valued all over the world in culinary preparations and for its medicinal properties. Ginger propagation is done through the underground rhizomes but many diseases like bacterial wilt and soft rot are mainly transmitted by rhizomes. Micropropagation by using tissue culture techniques is a proper alternative to produce disease-free clones. So to conserve the locally available germplasm, which is under threat due to rhizome borne diseases, seed production through micropropagation is undertaken at author's institute. The present paper would deal with propagation aspects of these three species in detail.

Keywords: Glory lily, ginger, gingko, propagation

O/1.07

Ex situ Conservation of Wild Relatives of Spices and Medicinal Plants from the Andaman Islands

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Spices, medicinal and aromatic plants play important roles in food and health security of mankind since time immemorial. Conservation and utilization of indigenous species of these resources complement the increasing demand for natural products that have beneficial impact on human health and nutrition. The wild relatives of spices as well as medicinal and aromatic plants from the Andaman and Nicobar Islands are a lesser-known group in the Indian context and comprise quite a number of endemics and other extra Indian taxa with potential economic values. The group of 836 Islands situated in the Bay of Bengal is far off from the Coromandel Coast of the Peninsular India, which encompass a peculiar agro-climatic ecosystem. The insular flora consists of *ca*. 2,314 angiosperm species belonging to 181 families, representing high degree of plant diversity. This region is susceptible to various ecological, environmental and anthropogenic instabilities which affect the insular flora. In this context, author's institute established a Conservatory of Plants of Andaman and Nicobar Islands in 1994. Currently, it turned to be a center of *ex-situ* conservation of insular flora outside the islands consisting of over 160 taxa. Among other R&D activities, various wild relatives of spice and aromatic plants are being conserved, characterized and evaluated for the last three decades. The current paper emphasizes the characterization on wild relatives of pepper, betel, nutmeg, large cardamom etc. at the institute.

Keywords: Andaman & Nicobar Islands, angiosperms, characterization, germplasm

Theme 1: Genetic Resources, Conservation and Crop Improvement in Spices and MAPs

Poster Presentations

P/1.01

Exploration, Collection and Characterisation of *Bergenia ciliata* (Haw.) Sternb. Accessions of Sikkim and Darjeeling Himalayas

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Bergenia ciliata, also known as *Pakhanbed*, is a useful medicinal herb used in numerous indigenous Indian medicinal systems. Although the entire plant is used medicinally, the rhizome is the most valuable part. In *B. ciliata*, developing cultivars with high rhizome yield and quality is a significant breeding goal. There has been minimal effort made to collect germplasm and study its diversity, which has impeded the route to generating high yielding medicinal plant types for further utilization. The research's primary intent was to explore the natural population and preserve the existing variability. An exploration and gathering attempt for wild populations was made in the Sikkim and Darjeeling Himalayas between 2017 and 2021. In order to acquire and understand distribution patterns and population status in the natural context, eight explorations were conducted, and twenty-five accessions were collected and regenerated *ex situ* for conservation and diversity investigations. For all the traits except inflorescence per plant, analysis of variance revealed substantial variations among the studied populations. The most significant range of genotypic and phenotypic coefficients of variation was seen for variables such as rhizome dry weight, rhizome fresh weight, rhizome diameter and plant height. These traits indicated presence of additive gene action in the current study as they showed high heritability and genetic advance mean value. Studies on correlation revealed a positive and substantial relationship between rhizome fresh weight, diameter and length. The first three Principal components explained 72.06% of the variation in the attributes tested. The germplasm will serve as a starting point for boosting *B. ciliata* production.

Keywords: Correlation, Exploration, Principal component, Variability

P/1.02

Survey, Collection and Morphological Characterisation of Germplasm of *Swertia chirayita*- a Critically Endangered Medicinal Herb

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Chirayita (*Swertia chirayita*) is a Himalayan medicinal herb that has been classified as Critically Endangered by the IUCN. The entire plant has traditionally been used to cure a number of diseases in both formal and traditional medicinal systems. Between 2016 and 2019, six surveys were conducted in four districts of Sikkim and two districts of West Bengal to study the natural population and conserve variability

in the field and seed gene bank. Twenty-five (KSC 1-25) germplasm were collected and regenerated for *ex-situ* conservation and breeding purposes. The germplasms were characterized for twelve characters using NBPGR minimal descriptors. Significant differences were found between germplasm for seven characters evaluated, with the exception of number of branches per plant and leaf length, indicating the presence of variability in the materials that can be exploited by selection. Among the collected germplasm, the highest plant height (125.50 cm), number of branches per plant (8.0), number of inflorescences per plant (203.6), number of flowers per plant (671.67), fresh weight (113.80 g), and dry weight (57. 28 g) were observed in KSC-8. The number of inflorescences per plant, root length and diameter of all germplasms varied considerably with altitude. The identified germplasms will serve as a foundation for future breeding programs, genetic improvement, and commercial cultivation, as well as potential sources of high-quality germplasm to increase the quality of herbal products and relieve pressure on fragile wild populations.

Keywords: Altitude, conservation, morphology, yield

P/1.03

In Vitro Propagation and Conservation of *Zingiber wightianum* Thwaites: an Important and Endangered Wild Relative of *Zingiber* Species

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Zingiber, a genus comprising of nearly 150 species of economic, medicinal and horticulturally important rhizomatous plant species, is distributed across tropical and subtropical Asia and Far East Asia. These plants are sources of natural antimicrobial, pharmaceutical and antioxidant products. *Zingiber wightianum* Thwaites, a crop wild relative (CWR) of cultivated ginger is classified as endangered due to deforestation and is rarely found in its natural habitats. It is used in the traditional medicine systems for the treatment of pain, swelling, as a liver protectant and also as a biopesticide. The plant is naturally propagated by rhizomes; however, rhizome propagation carries with it the threat of several soil borne pathogens along with the requirement of large quantity of seed rhizomes. An efficient micropropagation protocol was developed to produce large number of plantlets from rhizome buds of *Z. wightianum*. Surface sterilized rhizome buds were cultured onto 21 different media combinations comprising of Murashige and Skoog (MS) medium supplemented with varying concentrations of three phytohormones, *viz*. 4.44 – 22.22 µM 6-benzylaminopurine (BAP), 4.14 – 20.74 µM *meta*-Topolin (*m*T) and 2.68 µM 1-Naphthylacetic acid (NAA), alone or in combination. Shoots and roots were induced on all the tested media combinations; however, the best response with the highest number of shoots (7.08 ± 0.36) was recorded on MS medium supplemented with 20.74 µM *m*T alone. The longest shoots were recorded on 4.14 µM *m*T containing medium (7.78 cm ± 0.13) and best root induction was observed on hormone free basal MS medium (28.7 ± 1.34). Well-developed plantlets were primary hardened under mist chamber in autoclaved soilrite and acclimatized plantlets were transferred to field. Genetic stability of the micropropagated plants was confirmed using 20 ISSR markers and true-to-type plants were confirmed. The developed protocol can be utilized for large scale propagation of *Z. wightianum* for its conservation as well as use in industry.

Keywords: rhizomatous, medicinal plant, *meta*- Topolin, micropropagation

P/1.04

Molecular Characterization of Veldt Grape (*Cissus quadrangularis*) Ecotypes using RAPD- PCR Technique

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Cissus quadrangularis commonly known as veldt grape, is an ancient medicinal plant native to Sri Lanka and India. Among the fifty ecotypes collected from different geographical locations of Tamil Nadu, five morphologically superior ones were subjected to genotyping through molecular (RAPD) markers. The RAPD analysis was carried out using a set of 12 decamer random primers for DNA amplification through PCR assay. Out of 12 RAPD primers screened, 8 primers produced clear polymorphic bands in all the tested 5 ecotypes (TNCq32, TNCq34, TNCq29, TNCq23 and TNCq9). A total of 128 bands were detected from 8 DNA templates of different ecotypes, among which 63 (50.54%) bands were polymorphic revealing a high degree polymorphism among the ecotypes. The range of polymeric bands in *C. quadrangularis* ecotypes was 5-12. The average number of bands per primer was 7.88. The highest number of bands *i.e.* 12 were generated by the primer RPL-5 followed by RPL-8 (10 bands) and RPL-10 (10 bands). In the present study, the PIC values ranged between 0.38-0.46. The mean PIC score for all loci was 0.43. The linkage and divergence nature of the ecotypes computed by using UPGMA cluster analysis to generate a dendrogram of 5 genotypes of *C. quadrangularis* revealed two major clusters along with two minor sub clusters. Major cluster I had only one ecotype (TNCq32) possessing circular leaves with dark green coloured stem and produced flowers. The ecotypes 34 and 29 were found to have the highest similarity (SI=0.64807) followed by 34 and 23 (SI=0.63245).

Keywords: polymorphism, UPGMA cluster analysis, variability

P/1.05

Effect of Phytohormone *meta*-Topolin on *in vitro* Propagation of *Rubia cordifolia* L.

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The presented research is focused on *Rubia cordifolia* L. (Indian madder), an important medicinal plant species native to India. Due to its exceptional therapeutic properties and commercial value, *R. cordifolia* has faced excessive collection from the wild, leading to its vulnerability and endangerment. To address this issue, *in vitro* propagation techniques were explored using the natural cytokinin, *meta*-topolin (*m*T), known for its efficacy in enhancing plant multiplication. Sixteen different media combinations were tested, including cytokinins such as BAP, Kn, 2-iP (1.0 mg/L) and *m*T (0.5-5.0 mg/L), for *in vitro* shoot multiplication. The results indicated that *R. cordifolia* demonstrated 100% shoot induction on all tested media combinations. Furthermore, *m*T significantly influenced shoot production, with 2.0 mg/L concentration proving more

effective, with the highest number of shoots (13.2 ± 0.27) and nodes (28.4 ± 0.71) after 16 weeks and 26.8 ± 0.35 shoots, 48.7 ± 0.70 nodes after 24 weeks. Best *in vitro* rooting was achieved using microshoots taken from plants grown on MS medium on half strength MS media supplemented with 2.0 mg/L IBA, which produced the most roots (13.2 ± 0.27) after 8 weeks. The different cytokinins including *m*T, were evaluated for their effect on *in vitro* rooting. The *meta*-topolin at 2.0 mg/L displayed the favorable outcome, promoting a substantial number of roots (20.2 ± 0.62). Following acclimatization, the rooted plants exhibited a 100% survival rate. Additionally, the genetic fidelity of the *in vitro* regenerated plantlets was assessed using 20 ISSR markers, demonstrating no discernible differences between mother plants and the *in vitro* propagated plantlets, confirming their genetic stability.

Keywords: genetic stability, *manjishtha*, tissue culture

P/1.06

Genetic Diversity Studies in *Kantakari* (*Solanum surattense* Burm. f.) Accessions

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The study was conducted to study the genetic association between nineteen quantitative traits of fifty-five yellow- berried nightshade/ *kantakari* (*Solanum surattense* Burm. f.) accessions. *Kantakari* often grows as a spreading annual with 4–7 branches. Thorns are found on every part of the plant, including stem, leaves, petioles, internodes, and even the calyx. Violet flowers are present in clusters rather than solitary blooms and are medium in size. Solasodine, a glycoalkaloid produced by the species, is well recognised. It is utilised commercially as a prototype in the steroid medicine industry to create corticosteroids and it is also one of the ingredients in *Dasamoolam*. The experiment material was evaluated in ridged rows of 10 m length at the authors' institute during Rabi, 2021-22. NMPB recommended package of practices was followed to raise the healthy crop. Maximum variation was observed for number of flower clusters per plant, leaf width, petiole length, days to first flowering, number of berries, fresh single berry weight, fresh berry yield per plant and dry berry yield per plant. Correlation studies disclosed that dry berry yield per plant was highly significant and positively related with number of berries, fresh berry weight, dry single berry weight, fresh single berry weight, berry diameter and plant spread (N-S). Selection based on these parameters would ultimately improve berry yield in *kantakari*. Nine ideal accessions *viz*. *Ss*-13, *Ss*-44, *Ss*-1, *Ss*-34, *Ss*-12, *Ss*-17, *Ss*-7, *Ss*-57 and *Ss*-33 were identified for the traits such as early maturity, number of branches per plant, less number of thorns, flower cluster per branch, number of berries, fresh and dry berry yield per plant in this study. Quantification using HPTLC revealed accession *Ss* – 48 (2.01%) with the highest solasodine content. Hence, these accessions could be employed as source lines in breeding programmes to produce desired segregates.

Keywords: correlation, HPTLC, solasodine, Solanaceae

P/1.07

Genetic Variability for Phytochemicals and Mineral Contents in Indian Pennywort (*Centella asiatica* L.) Accessions of Hill Zone of Karnataka

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Indian Pennywort (*Centella asiatica* L.) is an underutilized nutraceutical herb. An experiment was carried out at College of Horticulture, Mudigere, Karnataka, India during 2022-23 to know the variation in nutraceutical components of accessions collected from various ecological regions of Hill Zone of Karnataka (20 accessions with 3 checks *viz.* Arka Prabhavi, Arka Divya and Vallabh Medha) using Completely Randomised Design with two replications. The results showed wide variations among the accessions for phytochemical constituents *viz.* ascorbic acid (28.31 - 69.04 mg/100g), total carotenoids (3.67 - 16.49 mg/100g), total anthocyanins (26.47 - 140.87 mg/100g), total phenols (51.73 - 325.66 mg GAE/100g), total flavonoids (87.99 - 169.66 mg QE/100g) and tannins (125.15 - 293.16 mg TAE/100g); oxalates (20.01 - 46.24 mg/100g); antioxidant activity (20.22 - 77.37%) and minerals *viz.* phosphorus (13.49 - 29.02 mg/100g), potassium (293.82 - 576.41 mg/100g), calcium (1292.37 - 3391.00 mg/100g), iron (127.55 - 342.02 mg/100g) and zinc (23.80 - 52.97 mg/100g). Among 23 accessions tested, Acc. 22 recorded significantly highest total flavonoids (169.66 mg QE/100g), tannins (293.16 mg TAE/100g), antioxidant activity (77.37%) and oxalates (20.01 mg/100g) compared to other accessions and checks. Significantly highest ascorbic acid (69.04 mg/100g), total carotenoids (16.49 mg/100g), anthocyanin (140.87 mg/100g) and total phenols (325.66 mg GAE/100g) were recorded in accessions Acc. 9, Acc. 23, Acc. 26 and Acc. 8, respectively. The accessions Acc. 10, Acc. 23, Acc. 7 and Acc. 6 showed significantly superior phosphorous (29.02 mg/100g), calcium (3391.00 mg/100g), iron (342.02 mg/100g) and zinc (52.97 mg/100g), respectively compared to checks. Higher GCV and PCV were recorded for ascorbic acid, total carotenoids, anthocyanin, total phenols, oxalates, antioxidant activity, iron and zinc. Moderate GCV and PCV were registered for total flavonoids, tannins, phosphorous and calcium. Moderate GCV and higher PCV estimates were noticed for potassium. Heritability and GAM estimates were high for all parameters.

Keywords: antinutritional factors, antioxidants, *mandukparni*, phytochemicals

P/1.08

Nutritional Profiling of Indian Pennywort (*Centella asiatica* L.) Accessions of Western Ghats Region of Karnataka

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Centella asiatica L. is an important medicinal cum nutraceutical herb, which is known to possess a plethora of medicinal properties, primarily as a brain tonic to enhance the memory power. The herb also contains significant nutritional qualities. To assess the nutritional composition in 20 *Centella asiatica* L. accessions collected from the Western Ghats region of Karnataka and three checks *viz.* Arka Prabhavi, Arka Divya and Vallabh Medha), an experiment was carried out using CRD design with two replications during *Rabi*-summer of 2022-23. The selected accessions were analysed for their proximate components at fifth month after planting. The accessions differed significantly with respect to the proximate composition. A wide range of variations were observed for the moisture (84.69 - 89.88% FWB), protein (11.50 - 22.19% DWB), fat (1.24 – 6.03% DWB), crude fibre (14.67 – 24.50%), ash (10.91 – 17.2%) and total carbohydrates (26.05 – 41.96% DWB). The maximum protein (22.19% DWB), fat (6.03% DWB), crude fibre (24.50% DWB), ash (17.2% DWB) and total carbohydrates (41.96% DWB) was recorded in accessions Acc. 21, Acc. 23, Acc. 8, Arka Divya and Acc. 14, respectively. Whereas, the accessions Acc. 14, Acc. 24, Acc. 23, Acc. 3 and Acc. 6 recorded the minimum protein (11.50% DWB), fat (1.24% DWB), crude fibre (24.50% DWB), ash (17.2% DWB) and total carbohydrates (26.05% DWB), respectively. The accessions are considerably high in crude fibre and carbohydrates, which could be used as supplements to improve the health of the general public.

Keywords: accession, crude fibre, carbohydrates, proximate, variability

P/1.09

Genetic Diversity Analysis of *Garcinia indica* (Dupetit- Thouars.) Choisy Based on Morphological and Molecular Markers

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Kokum [*Garcinia indica* Choisy (Thouras], is an important perennial tree species belonging to the family Clusiaceae. The species is native to the South-Western India. A set of forty three accessions are being maintained at the field gene bank of ICAR-NBPGR Regional Station, Thrissur. These germplasm were collected from twenty-nine locations representing four states *i.e.* Karnataka (34), Kerala (6), Maharashtra (2) and Goa (1). Twenty-nine accessions were subjected to morphological analysis. Based on morphological data, the accessions IC342306 and IC342322 collected from Uttar Kannada and Shivamogga, respectively were most similar to each other with a minimum pairwise distance value of 1.19, whereas IC550571 and IC552528 collected from Trissur and Kodagu, respectively were most distant with 9.95 value. Fifty ISSR

primers were screened and fourteen were identified with good amplification and these were used for diversity analysis. IC409060 and IC550571 collected from Kasaragod and Thrissur, respectively were the most similar with a minimum distance based on 72 ISSR and 10 SSR markers. Collections from Uttar Kannada and Trissur (IC342306 and IC550572) were the most distant with maximum distance value of 0.568. The gene flow among the accessions was 33%. This study revealed sufficient diversity in the field gene bank of NBPGR regional station, Thrissur.

Keywords: Accessions, Field gene bank, Gene flow, Kokum, Morphological analysis

P/1.10

Phytochemical Diversity of *Tinospora cordifolia* (Willd.) Accessions from Northern districts of Kerala

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Tinospora cordifolia (Willd.) is known as *Chittamruthu* (Malayalam), *Giloy* (Hindi) and *Guduchi* (Sanskrit). It is a perennial climber of the Menispermaceae family in which stem is the economic part. *T. cordifolia* is widely available throughout Kerala and its genetic diversity analysis could help in identification of superior genotype with optimum phytochemical concentration *viz*. alkaloid, flavonoid, phenol, saponin and cardiac glycoside content, which could be used for preparation of various Ayurvedic medicines. In the present study, 25 accessions were collected from different locations of 13 Agro- Ecological Units (AEU) belonging to Northern Kerala and its phytochemical diversity was studied. The accession collected from Thavanoor (10º 50’ 52.3”N and 76º 00’ 32.7”E), Malapuram, Kerala belonging to AEU 6 recorded highest total flavonoid content, total phenol content and cardiac glycoside *viz*. 54.29 µg/ mg Quercetin Equivalent, 116.54 µg/ mg Gallic Acid equivalent and 25.87 µg/mg Diosgenin Equivalent, respectively. The highest total alkaloids (112.27 µg/ mg Atropine Equivalent) and total saponin content (72.84 µg/ mg Digitoxin Equivalent) were found in accessions collected from Puthuppariyaram- Palakkad (AEU 22) and Kelakam-Kannur (AEU 15).

Keywords: alkaloids, diversity analysis, Menispermaceae, Saponin

P/1.11

Conservation of Genetic Resources of Turmeric: an Overview

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Turmeric is the important spice crops from the point of foreign earnings for Indian economy. It has been valued for various properties including flavoring, colouring and taste to the food products as a spice, apart from uses in the confectionaries, dye in textiles, pharmaceuticals and perfumeries. It is a rhizomatous crop with vegetative propagation and lack of hybridization has been considered as a factor that leads to lesser genetic diversity, a pre-requisite for crop improvement programmes. Germplasm conservation plays role in

development of cultivar with high rhizome yield and quality traits (Curcumin). Totally 3,351 germplasm of both indigenous and exotic have been collected and maintained in the different central and state agricultural universities through coordination of ICAR-NBPGR and other projects. The desirable traits of these lines can be utilized in the crop improvement programmes. In *in situ* conservation technique, rhizomes are kept unharvested under thick mulching, which could be maintained and utilized for the subsequent season. Similarly in *ex situ* conservation, seed rhizomes are stored in pits of convenient sizes in sheds or put in pits in layers along with well dried sand/ saw dust. Rhizomes could also be preserved in modified atmospheric storage at 7.2-10.0 ˚C with 75% relative humidity for 16-24 weeks. Genetic stability was maintained under *in vitro* regenerated plants of turmeric using isoenzyme pattern for 8-18 months without sub culture at 5, 10 and 15º C. Production of synthetic seeds in turmeric under *in vitro* condition using sodium alginate (4%) was found to be the best matrix and complexing agent for encapsulation and regeneration of *in vitro* buds. Use of GIS for mapping of trait specific germplasm in relation to bioactive compounds, biotechnology tools like *in vitro* storage/cryopreservation, use of molecular markers like SSR/SNP to understand the diversity and awareness generation related to patenting, farmer's right and benefit sharing are important. Thus, the present review would cover these aspects in detail.

Keywords: Cryopreservation, *in vitro* culture, rhizomes, synthetic seeds

P/1.12

Molecular Characterization of Turmeric Landraces/ Accessions Prevailing in Karnataka

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Turmeric (*Curcuma longa* L.) is an important sacred and ancient spice of India. India is the largest producer, consumer and exporter of turmeric in the world. In Karnataka, turmeric is being cultivated since ancient days but farmers do not know the varieties under cultivation. Hence, the present investigation was carried out at College of Horticulture, Bangaluru during 2017- 2020 in which surveys were conducted and 112 landraces/accessions from 10 districts, covering 14 talukas 58 villages of potential turmeric growing areas of Karnataka were collected. This study was conducted to understand the similarity between accessions and known varieties, and also to identify identical accessions. These turmeric accessions and known varieties were genotyped with 37 SSR markers. The highest number of 6 alleles per marker was observed with CUMISAT 8, while five number of alleles per marker was recorded for 3 markers *viz*. CUMISAT 13, CUMISAT 22 and CUMISAT 30. Eight markers recorded 4 alleles, five markers registered 3 alleles, fourteen markers recorded 2 alleles and five markers recorded only one allele. These genotypic data of accession was grouped into 13 clusters and 15 solitary clusters. The cluster 6 occupied maximum number of accessions (36), followed by cluster 2 (34), cluster 1 (18) and cluster 4 (8), and the minimum number of one accession found with 15 solitary clusters. Therefore, these 15 accessions viz., TC-142, TC-137, TC-134, TC-99, TC-97, TC-85, TC-73, TC-72, TC-69, TC-68, TC-67, TC-61, TC-60-2, TC-58 and TC-57 were found to be very diverse compared to other accessions. Cluster 6 recorded 36 accessions and showing more similarity to Prathibha and Pragati. Similarly, the cluster 4 covering 8 accessions had shown more similarity with Alleppey Supreme and BSR 2. This molecular analysis clearly showed that, even though morphologically accessions showing similar phenotypes and they are genotypically different.

Keywords: CUMISAT, TC-Turmeric, Cluster, Darwin, Prathibha

P/1.13

Induced Mutagenesis for Development and Identification of Elite Mutants in *Stevia rebaudiana* Bertoni

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Stevia, a natural sweetener with nutritional, therapeutic and industrial importance is being used across the globe. It is native of Paraguay and South-West Brazil and is also known as sweet leaf, sugar leaf, sweet honey leaf and *methi tulsi*. Stevia leaf contains more than 20 steviol glycosides including stevioside and rebaudioside A, B, C and D. It is 100–300 times sweeter than sucrose and widely used as zero calorie sweetener all over the world on commercial scale. It produces flowers at an early stage under Indian photoperiod condition, thus leading to poor leaf yield for sweetener extraction. Additionally, meager breeding work has been done in developing suitable cultivars under Indian conditions. Thus, the impact of gamma irradiation and ethylmethane sulphonate (EMS) in developing new stevia mutants was studied. Seeds of stevia cv. CIM Madhu were collected and exposed to 50, 100, 200, 300, 400, 500 and 600 Gy gamma irradiation dosages and 0.1%, 0.2%, 0.4%, 0.6%, 0.8% and 1.0% EMS concentrations to determine the LD_{50} value. The LD_{50} was determined by plotting a simple regression graph based on seedling survival percentage against gamma irradiation dosages and EMS concentrations. The results revealed that LD_{50} was 150 grays for gamma rays and 0.8% for EMS. After ascertaining LD_{50} value in both the treatments mutation was induced to create variability for morphological and other desirable traits. Variations were observed in leaf morphological characters *viz*. leaf tip, base, margin and shape in mutant population along with growth parameters. Plants with desirable traits were vegetatively propagated and were forwarded to M_2 generation for breeding purpose.

Keywords: EMS, Gamma rays, LD_{50}, Mutation, Stevia

P/1.14

An Overview of the Genetic Improvement of Ashwagandha (*Withania somnifera*)

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Secondary plant metabolites from medicinal plants are a valuable source for human wellness. Ashwagandha contains several alkaloids, including withanolides, somniferine, somniferinine, somnine, withananine, withaferin, and withasomnine. Because secondary metabolites are mostly derived from ashwagandha's roots, the roots of ashwagandha constitute the economic component of the plant. Improvement of the yield and quality of medicinal plants is still a challenge. The High content of desirable compounds, absence of harmful substances, high dry matter content and high antimicrobial properties are the major breeding objectives for medicinal plant breeding. There are many breeding methods for genetic improvement *viz*. selection, hybridization, mutagenesis, polyploidy breeding, transgenic breeding, marker-

assisted breeding *etc*. Selection is the earliest method of plant breeding based on elementary knowledge of the laws of inheritance. The selection of plants within landraces is based on the assumption that the progenies of the best individuals are expected to be superior than the progeny of random samples of the population. In hybrid breeding, two genetically diverse homozygotic parental lines are crossed with each other to produce a hybrid. Mutation breeding is a technique of creating heritable variability through altering genes through induction of mutations by physical or chemical mutagens followed by selection during various generations for desired objectives. Marker-assisted breeding uses DNA markers associated with desirable traits to select a plant for inclusion in a breeding program early in its development. It is based on DNA polymorphism. In ashwagandha, there are limitations associated with research on traditional and modern breeding methods, which are discussed in this paper.

Keywords: Improvement, medicinal plant, selection, traditional breeding methods

P/1.15

Studies on Path Analysis and Selection Indices in Ajwain (*Trachyspermum ammi* L.)

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The present investigation was carried out with fifteen genotypes including three checks of ajwain. The experiment was conducted in Randomized Block Design with three replications during *rabi* 2020-2021 at Chilli and Vegetable Research Unit of authors' organization. The estimates of mean sum of squares due to genotypes were highly significant for all the characters under study, with values of higher magnitude for number of umbels per plant. This was followed by plant height at maturity, days to 50% flowering, days to first flowering, days to maturity, number of umbellates per umbel, seed yield per plant, number of primary branches per plant and test weight indicating considerable amount of variability for these characters and amenability to improvement. In the present study, the mean performance of genotypes revealed a wide range of variability for all the characters. Genotypic correlation studies between yield and yield contributing traits revealed that the seed yield per plant was positively and significantly correlated with plant height at maturity, number of primary branches per plant, number of umbels per plant, number of umbellates per umbel and test weight. These associations indicated that improvement in seed yield per plant can be achieved by improving these characters. The genotypic path coefficient analysis indicated that days to first flowering, number of umbels per plant, number of umbellates per umbel and test weight had positive direct effect on seed yield per plant. In this present investigation, selection based on three characters (number of umbels per plant + number of umbellates per umbel + test weight) showing genetic gain (2.444) and relative efficiency (104.504%) was observed to be more desirable and pragmatic to use than those based on four or more characters.

Keywords: Genetic correlation, Path analysis, Umbels, Umbellate

P/1.16

Evaluation of Tamarind Genotypes for Growth, Yield and Quality under Akola Condition of Maharashtra

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The experiment was conducted at All India Coordinated Research Project for Dryland Agriculture of the authors' institute to evaluate tamarind genotypes for growth, yield and quality and identify suitable genotypes for these traits. The experiment was laid out in one-way classification with twenty-five genotypes. Genotype DAAT-W-1 showed maximum length of pod (19.46 cm), while minimum number of seeds (4.00 per pod) was recorded in DAAT-WF-1. Highest pod yield was obtained in genotypes DAAT-W-1 and DAAT-E-5 (30 kg/ tree); while the lowest seed weight per pod (2.81 g) and shell weight per pod (2.36 g) was observed in DAAT-E-5. The lowest pod yield per tree was observed in DAAT-WF-1 and DAAT-E-6 (2.25 kg/ tree). The maximum girth of trunk at 1m height was found in genotype DAAT-E-4 (201 cm) while widest pods (2.83 cm) were observed in DAAT-WF-4. The highest plant growth in terms of plant height was observed in DAAT-E-4 (20 m). Among the different tamarind genotypes, initiation of flowering started during the month of April to June. Tamarind genotype DAAT-W-4 performed better for quality attributes. Maximum pulp weight per pod (5.82 g), pulp (46.60 %), TSS (53.70 ^{o}Brix), titratable acidity (18.01%), tartaric acid (17.04%), reducing sugars (28.66%) and total sugars (33.85%) were observed. Lowest vein weight was found in genotypes DAAT-W-8 and DAAT-E-4 (0.28 g per pod), while, the highest vein weight was observed in genotypes CAAT-WF-7 (0.69 g per pod).

Keywords: fruit traits, seed traits, germplasm, tree

P/1.17

Genetic Variability and Evaluation of Tamarind Genotypes for Morphological and Yield Contributing Characters

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Present investigation is carried out for five consecutive years during 2018-2022 to find out genetic variability on the basis of yield and yield attributes of different genotypes, which could be helpful to conserve and utilize valuable germplasm in tamarind improvement programmes. It was observed that the available tamarind germplasm has variability in terms of growth habit, plant stature, bark colour, branching habit, pulp, endocarp colour, fruit characters including qualitative and quantitative parameters. The length of pod showed significant variation, highest being in the genotype NGNT 5. The thickness of pod (cm) was recorded the highest in NGNT 5 and MGT 1/1, while width of pod (cm) was observed to be the highest in MGNT/5 1/1, followed by PKM. Weight of pod was the highest in MGNT/ 1 (14.1 g). Number of pod per kg recorded maximum in MGT 2/3 followed by DTH 8/1 and MGNT 1 *i.e.* 117, 110 and 108 /kg, respectively. The highest shell weight per pod was observed (4.65 g) in MGT 1/1 followed by PKM 1 (4.10 g). Rag weight per pod was highest in MGT 1/1 (0.50 g) and MGT 4/1 (0.45 g). The highest pulp weight per pod of 13.85

g was noticed in MGT 5 followed by MGT 1/1 (9.8 g) and PKM 1 (9.4 g). The genotypes with superior pulp recovery and pulp: shell ratio were identified. Thus, these genotypes could be of practical utility for formulating selection indices in tamarind crop improvement programmes.

Keywords: Conservation, germplasm, improvement, variability

P/1.18

Genetic Variability and Correlation Studies in Turmeric

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The present investigation was carried out in Randomized Block Design with two replications to evaluate twenty genotypes of turmeric for different traits. The highest genotypic coefficient of variation as well as phenotypic coefficient of variation were observed for leaf area, number of primary rhizomes, girth of primary rhizome, length of mother rhizome, weight of primary rhizome and weight of mother rhizome. The highest estimates of heritability were recorded for leaf area followed by length of primary rhizome, girth of primary rhizome, yield of finger rhizome per plant and weight of mother rhizome. Highest genetic advance was also observed for leaf area followed by number of primary rhizomes and girth of primary rhizome; however, it ranged from 2.88 to 98.61% for all the studied characters. From the genotypic and phenotypic correlation studies between yield contributing traits it was revealed that, total rhizome yield per hectare was positively and significantly associated with leaf area, number of primary rhizomes, weight of primary rhizome, length of primary rhizome, weight of primary rhizome, yield of rhizomes per plot and yield of finger rhizome per plant. However, the characters like plant height, Number of leaves and number of tillers had positive but non- significant correlation with rhizome yield per hectare. Path analysis revealed positive direct effect on rhizome yield per hectare through plant height, number of leaves, weight of mother rhizome, yield of finger rhizome per plant and yield of rhizome per plot. On the basis of yield and yield contributing characters, the genotypes *viz*. PDKV Waygaon, AKTL-13, AKTL-8, AKTL-11, AKTL-17, AKTL-19 and Gondia Haladi-1 were found to be promising for future improvement programme.

Keywords: Correlation, genetic variability, rhizome, screening

P/1.19

Genetic Variability, Correlation and Heritability in Ashwagandha Germplasm

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An experiment was conducted with 16 diverse genotypes of Ashwagandha using Randomized Block Design (RBD) with two replications during the *Kharif* 2021-22. The results of analysis of variance showed presence of significant variability among the studied genotypes. The GCV and PCV for characters like root length, root diameter and dry root yield per plant were high indicating wider genetic variability for the mentioned traits. Genotypic correlation was found higher than phenotypic correlation in most of the characters suggesting less control of environment on the characters. Additive gene action was evident in the

characters like number of branches, root length, root diameter and dry root yield per plant as high heritability was found coupled with high genetic advance. The positive and significant correlation was observed in root diameter and dry root yield. Therefore, selection of above characters will be rewarding to improve the yield and quality of roots in Ashwagandha.

Keywords: Indian ginseng, PCV, Solanaceae, root

P/1.20

Assessment of Molecular Diversity Employing DNA Markers in *Bacopa monnieri* L.

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With increasing demands for herbal drugs, the natural populations of brahmi (*Bacopa monnieri* L.) are threatened with over exploitation leading to depletion of valuable genetic resources. Much of the significant work has been done on its medicinal importance and only limited work has been done to assess its genetic diversity using molecular markers. Hence, there is a need to study the genetic diversity at DNA level so that the genotypes could be classified and used more effectively for their conservation and breeding programs. With these points in consideration, the present research work was carried out to assess molecular diversity using 15 RAPD markers in 50 brahmi genotypes. Of these, 11 primers showed 100% polymorphism and were found efficient in all the band statistics. Polymorphic information content (PIC) among markers ranged from 0.71 to 0.97 with mean of 0.92. The maximum PIC value 0.97 was found in OPAB-08, OPAB-19, OPAC-20, OPB-20, OPB-12, OPM-01 and the PIC was least for the primer OPM-20 (0.87), followed by OPM-02 (0.71). Whereas, the observed heterozygosity (H_O) ranged from 0.667 to 1.000 with a mean of 0.960. The maximum (H_O) value (1.000) was found for majority of the primers and minimum (H_O) value was recorded for the primers OPM-02(0.667) and OPAB-17 (0.818). Similarly, the expected heterozygosity (H_E) ranged from 0.74 to 1.00 with a mean of 0.94. The maximum (H_E) value was found for primer OPI-19 (1.00) and it was low in the primers OPM-20 (0.89), OPN-10 (0.89), OPM-02 (0.74). Further, dendrogram showed six clusters and the genotypes were grouped into cluster I (25), cluster II (19), cluster III (2), cluster IV (1), cluster V (2) and cluster VI (1). The maximum inter cluster distance was recorded between cluster I and cluster IV was 162.845 followed by cluster I and cluster V (154.664). PCA analysis also showed similar pattern of distribution of brahmi genotypes as shown in dendrogram. The diverse genotypes IIHR BM-31 and IC 468878 were identified through molecular diversity analysis.

Keywords: Molecular diversity, observed heterozygosity, polymorphic information content, RAPD markers

P/1.21

Response of Fennel Mutant Lines Raised under Water Deficit Condition at Seedling Stage

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Fennel (*Foeniculum vulgare* Mill), which belongs to the family Apiaceae, is an annual aromatic herb producing yellow flowers. Moisture stress is the most common environmental stress and its effect on plant growth and yield largely depends on the genotypes, stress duration, durability and rate of water shortage. It should be noted that fennel wildly grows in arid and semiarid regions in India. Water stress is known to limit the growth of plants and can cause severe decline in its production and quality. Water deficit in fennel leads to reduction in plant height, number of branches and seed yield. Looking into the problem, an experiment was conducted to screen out the drought tolerance mutant lines of fennel at seedling stage under laboratory condition. The moisture stress tolerance potential of 43 mutant lines was evaluated by imposing polyethylene glycol (PEG 6000)-induced drought. Results showed non significance differences when PEG was applied at 15 days old seedlings. Then the methodology was modified and PEG solution was applied regularly just after the sowing of seeds of difference mutant lines. Significant variations were recorded in the mean values of different morphological traits due to PEG-induced drought effects. The first effect of PEG was observed in terms of delayed seed germination. As the dose increased from 0 to 20%, seed germination was delayed. In control, seed germinated in 7.5 days, while at 20% PEG concentration it took 12.5 days for seed germination in mutant line M-1. Delayed seed germination was recorded in all the mutant lines. Shoot length, root length, fresh weight and dry weight were reduced at increased PEG concentrations. Under PEG induced moisture stress, highest shoot growth (9.2 cm), root length (4.8 cm), fresh weight (0.15 g) and dry weight (0.014g) were recorded in M-1 followed by M-14, M-18 and M-25. The robust clustering indicated that all the genotypes were clustered into three major groups. Thus, these lines could grow better under moisture deficit condition in arid and semi-arid regions during time of unpredictable climate change.

Keywords: *Foeniculum vulgare*, mutation, polyethylene glycol, seedling growth

P/1.22

Standardization of Seed and Vegetative Propagation Techniques in *Stereospermum saveolens* (Roxb.) De Wilde: a Threatened Medicinal Plant

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Stereospermum saveolens (Patala) is one of the most important drug of *Dashmoola* that has widely been used in Ayurvedic preparations. It contains many biologically active constituents like flavonoids, tannins and glycosides. The species has become threatened in the wild due to its overexploitation and unscientific harvesting. Reduced seed production has resulted into gradual erosion of its natural populations. Natural

regeneration of this species in nature is very meager due to poor germination rate and hence, its conservation is the need of the hour. An experiment was carried out to standardize seed and vegetative propagation for this very important medicinal plant. Among the different germination inducing treatments, seeds treated with GA_3 (200 ppm) showed early germination (23.73 days), highest germination rate (2.95%), seedling vigour index (6315.10), seedling height (68.40 cm), fresh weight (16.00 g) and dry weight of seedling (8.47 g). In case of vegetative propagation, hard wood cuttings and air layering were carried out. Cuttings treated with IBA (2000 ppm) had a significant positive effect on the percentage of rooting (33.41), sprouting (33.70) and number of days taken for sprouting (23.00). In air layering, branches treated with IBA (2500 ppm) had a significant influence on rooting (88.07%), number of days taken for root initiation (32.00), root diameter (3.53 mm), number of primary roots per layer (6.00), number of secondary roots per layer (40.17) and root length (13.03 cm). Results will be highly useful for large scale multiplication of this species.

Keywords: air layering, *dashmoola*, rooting, stem cutting

P/1.23

Identification and Characterization of Gamma Ray Induced Mutants of Stevia via Morpho-histological and Steviol Glycoside Analysis

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Stevia (*Stevia rebaudiana* Bert.) popularly known as ‘Sweet herb of Paraguay’, ‘Candy leaf’ or ‘Sweet leaf’ is a perennial highly-valued medicinal plant belonging to Asteraceae family. It is renowned for its economically important natural sweetening compounds (diterpene glycosides) and grabs commercial attention in the world market for its therapeutic properties. In order to meet the growing demand of these glycosides from farmers and pharmaceutical industries, *in vitro* mutagenesis can be a promising approach for enhancement of the steviol glycosides production. With this backdrop, the *in vitro*-regenerated nodal segments of stevia were irradiated to varied doses of gamma rays (5, 10, 15, 20, 25, and 30 Gy). After analyzing all the *in vitro* growth attributes, it was noticed that the 20 Gy was the optimum dose for development of potential mutant plantlets with desirable growth traits along with optimal survival rate. The *in vitro* morphological and histological parameters of the control (non-irradiated plantlets) and the putative mutants were studied during the successive generations. It was observed that there were significant variations in the shoot multiplication, plant height, internodal length, leaf size and shape of the putative mutants in comparison to the control. Similarly, micro-morphological assessment of semi-thin stem cross sections of putative mutants exhibited significant differences in the number of vascular bundles and cortex cells in comparison to the control. Higher steviol glycosides content were detected from the putative mutants, when compared with the control via HPLC analysis. Hence, the current investigation provides immensely useful information for the identification of novel mutants with enhanced steviol glycosides content.

Keywords: HPLC; *In vitro* mutagenesis; Morphology; Nodal segments; Putative mutants

Theme 2: Sustainable Production Technologies for Spices and MAPs

Invited Talks

Dr. P.M. Haldankar

Dr. P. M. Haldankar born in 1963 and recipient of 11 national and state level awards including Fellow of National Academy of Biological Sciences (2023), Girdhari Lal Chadha Award in Fruit Science (2021), Fellow of International Society of Noni Science (2018), Best Agricultural Scientist by Zee 24tas (2014), Vasantrao Naik Memorial Gold Medal (2012), NAAS- Tata Young Scientist award (2003) and Abasaheb Kubal Award (1998). He completed B.Sc. (Agri.) from MPKV, Rahuri in 1983 and M. Sc. (Agri.) and Ph. D. (Agri.) from Dr. BSKKV, Dapoli in the year 1985 and 2002, respectively. He developed 19 varieties of fruits, vegetables, plantation crops and spices. He is associated with development of varieties of horticultural crops *viz*. nutmeg (Konkan Swad, Konkan Sugandha, Konkan Shrimanti and Konkan Samyukta); cinnamon (Konkan Tej and Konkan Tejpatta); kokum (Konkan Amruta and Konkan Hatis); coconut (Pratap, D×T, D×T2 and Philippines Ordinary) and cashew (Vengurla 8 and 9). He contributed for development of technologies which are widely used and adopted by farmers and entrepreneurs *viz*. Spices- Air layering in cinnamon, softwood grafting in nutmeg; *Myristica Malabarica* rootstock for nutmeg; rapid multiplication of turmeric saplings in portrays; coconut- Mixed cropping of tree spices in coconut orchards; Mango- rejuvenation of old, unproductive orchards and production of high quality mango grafts; basin exposure for induction of flowering; pre-harvest bagging; Jamun- Girdling for induction of flowering. He had major role in for receiving Geographical Indication of Vengurla Cashew (GI No. 489) and Sindhudurg and Ratnagiri Kokum (GI No. 474). He also contributed for registration of five farmer's varieties and developed DUS guidelines for Nutmeg; descriptor for kokum. He was also involved in many externally funded projects at national and international level such as Centre of Excellence for mango under Indo-Israel work plan; Niche Area of Excellence project for mango. Dr. Haldankar published more than 75 scientific publications and 7 books in national and international reputed scientific journals. He has guided 13 Ph.D. and 26 M.Sc. students. He has handled many academic and administrative responsibilities in Dr. BSKKV, Dapoli *viz*. Director of Research, Associate Dean and Dean, Faculty of Horticulture *etc*.

IT/2.01

Improved Practices for Harnessing the Potential of Tree Spices

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India is known as 'land of spices'. Tree spices are an important group among spices and about 17 tree spices are grown in India. There is need to harness yield potential of tree spices owing to their economic importance and demand. The improved varieties with good yield capacity and quality have been developed in some tree spices *viz.* nutmeg (Konkan Swad, Konkan Sungadha, Konkan Sanyukta, Keralashree and Viswashree); cinnamon (Konkan Tej, Konkan Tejpatta, Navashree and Nithyashree); Kokum (Konkan Hatis and Konkan Amrita). Remarkable quality planting material of tree spices is being supplied to the stakeholders due to standardization of nursery and propagation techniques such as soft wood grafting in nutmeg and kokum; air layering in cinnamon *etc*. Tree spices are best suited for mixed and inter cropping in coconut and arecanut plantations as well as in kitchen gardens. These crops are also important components of agro-ecotourism. Development of appropriate practices of postharvest management are important for marketing of tree spices. Various processed products adds the value to tree spices and some of them are pickle, candy, sweet chutney, powder *etc*. from nutmeg; powder, quills, bark oil, leaf oil, bark oleoresin *etc*. from cinnamon and kokum syrup, RTS, amsul, seed oil, butter, agal *etc*. from kokum. The effective production technology must be coupled with proper dissemination technology. The initiative of Government of India through Mission for Integrated Development of Horticulture (MIDH) has helped for remarkable impact in area expansion under tree spices. Total 7 accredited and 15 implementing centers are participating in MIDH on Spices under jurisdiction of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for catering the objectives to produce genuine and quality planting material of tree spices recommended by university, front line demonstrations and transfer of technology through farmer training programmes in entire Konkan region of Maharashtra.

Dr. Manish Das

Dr. Manish Das, ARS, joined as Director, ICAR-Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR) and Project Coordinator of All India Coordinated Research Project on Medicinal & Aromatic Plants & Betelvine (ICAR-AICRPMAPB) since February 20th 2023. He was born in 1966, graduated in Agriculture in 1987 from RAU, Pusa and earned his Master and Ph.D. in Plant Physiology from IARI, New Delhi in 1990 and 1994, respectively. He joined ARS in 1995 and was posted in ICAR-CPRI, Shimla with subsequent posting at CPRIC, Modipuram and CPRI, Patna till 2003. He joined ICAR-DMAPR, Anand, Gujarat as Senior Scientist in 2003. Later, he was posted at ICAR HQ in Horticultural Science Division from 2012 till February 2023. During his career of 28 years, he has significantly contributed towards research and extension and also for the development of various important technologies related to potato storage, processing and value addition and in the field of medicinal plants. He has expertise in crop physiology, seed physiology and postharvest management of potato and medicinal plants. He has published more than 60 national and international research papers, edited 3 books, 10 book chapters and more than 40 popular articles/ bulletins/ manuals. He participated in many national and international seminars, symposiums, workshops and has delivered talks on radio and television. He has travelled foreign countries like the Netherlands, Belgium, Israel, Bangladesh and Nepal. He has been a Member, RAC and Member IMC of ICAR-CIARI, ICAR-CTCRI, ICAR-NRCO, ICAR-NRCSS and is presently serving as a Member of Board of Management of University of Horticultural Sciences, Bagalkot, Karnataka. He has received Young Scientist Award from Indian Society of Plant Physiology and several other awards. He is Fellow of Confederation of Horticulture Associations of India (CHAI), Fellow of Society for Conservation and Resource Development of Medicinal Plants (SMP) and Fellow of Society for Horticulture Research and Development (SHRD), President of Medicinal and Aromatic Plants Association of India (MAPAI) and is also holding honorary posts in several Scientific Societies.

IT/2.02

Hydroponics: Enhancing Phytochemical Content and Quality in Medicinal Plants

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Hydroponics, a soilless cultivation technique, has garnered attention for enhancing medicinal plant growth and phytochemical accumulation. It offers advantages over traditional methods, particularly in controlled environments, enabling rapid growth. However, phytochemical accumulation varies among the species. For instance, hydroponically cultivated *Stevia rebaudiana* demonstrated significant anti-hyperglycemic properties. Research on hydroponic and aeroponic cultivation found increased picroside content in *Picrorhiza kurroa* and enhanced ginsenoside content in *Panax ginseng*. Hydroponic cultivation of *Panax ginseng* demonstrated favorable conditions for the entire plant, including the root and leaf, with increased ginsenoside content. Optimization studies have been conducted for various medicinal and aromatic plants, including *Mentha* species and basils, observing biomass and chemical composition variations. Effects of hydroponic conditions on fenugreek and lemon balm growth, qualities, and constituents were explored. The suitability of hydroponics for medicinal and aromatic plants and the impact of light intensity and LED spectrum on phytochemical accumulation have also been investigated. The rhizofiltration potential of *Plectranthus amboinicus* in a hydroponic system was examined. Variability in biomass production and rosmarinic acid content was observed in basil plants grown hydroponically. Effects of macroelement omission in hydroponic systems on the growth and chemical composition of *Melissa officinalis* essential oil were examined. Hydroponic cultivation of medicinal plants shows promise in enhancing nutrient uptake and water-use efficiency. Hydroponics improves water-use efficiency alongside enhancing nutrient uptake in medicinal plant cultivation. Overall, hydroponics holds promise for cultivating medicinal plants, enhancing growth and optimizing phytochemical accumulation. Further research and implementation of hydroponic techniques are needed to fully harness these benefits in medicinal plants.

Keywords: bioactive molecules, hi-tech horticulture, soilless culture

Theme 2: Sustainable Production Technologies for Spices and MAPs

Oral Presentations

O/2.01

Influence of Crop Covers on Growth, Yield and Quality of Green Chilli under Vidarbha Conditions

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The experiment was conducted at Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to investigate the effect of different coloured crop covers on growth, yield, pest incidence and quality of chilli. The experiment was laid down in randomized block design with five treatments *viz*. T_1 - Standard package of practices without cover; T_2 – Absolute control without cover; T_3 - 17 GSM blue crop cover; T_4 - 17 GSM white crop cover and T_5 - 17 GSM red crop cover, and three replications. The maximum plant height at 45 days after transplanting was recorded in treatment 3 (37.53 cm), while maximum number of primary branches (11.09), maximum leaf area (33.69 cm^2), minimum days required for 50% flowering (46.68), maximum chlorophyll index (89.30), average number of fruits per plant (416.67), average fruit girth (4.78 cm), average fruit weight (6.12 g), maximum fruit yield per plant (2.58 kg), maximum yield per hectare (474.11 q) and minimum thrips (7.49) and white fly (5.32) population per three leaves were observed in treatment involving red crop cover. Significantly highest benefit cost ratio (3.48) was observed in 17 GSM white crop cover. From the above experiment, it was concluded that 17 GSM white crop cover was superior among all the treatments under Vidarbha conditions. Use of crop covers could reduce the incidence of sucking pests, minimize the excessive application of harmful pesticides and reduce the cost of production.

Keywords: Benefit cost ratio, crop covers, growth, quality, yield

O/2.02

In-vitro Shoot Proliferation Studies in Ginger (*Zingiber officinale* Rosc.)

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The present study was carried out with an aim to standardize the growth regulators requirement for *in-vitro* shoot proliferation in ginger variety Mahim Local during 2020-2022. Surface sterilization of explants (sprouted buds) was effectively achieved by using Bavistin (0.1%) + mercuric chloride (0.1%) for 15 min as it recorded lower contamination (20%) and higher survival (86.7%). Surface sterilized explants were inoculated onto Murashige and Skoog (MS) medium supplemented with various concentrations of 6-benzylaminopurine (BAP), kinetin (Kn) and 1-naphthaleneaceticacid (NAA). Explants cultured on MS media supplemented with 4 mg/L kinetin and 1 mg/L NAA exhibited significantly superior shoot proliferation (83.70%) after three weeks of culture. However, highest shoot multiplication (2.32/explant) was achieved in media supplemented with BAP (4.5 mg/L). The treatment combination of MS with Kin 4 mg/l+ 1 mg/ were proved to be significantly superior at 1% for high frequency multiple shoot induction. The response was shown a maximum of 10.65 shoot multiples after 3rdsubculture, followed by 6.83 shoot multiples after

2nd subculture and 3.76 shoot multiples after 1st subculture with significantly highest against control (MS medium without growth regulators). Therefore, MS media with above modification was found promising for *in-vitro* shoot proliferation studies in ginger.

Keywords: Cytokinin, micropropagation, rhizomatous, spice

O/2.03

Integrating Cultivation of Aquatic Medicinal Plants on Floating Rafts with Catfish Farming

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Catfish cultivation is a profitable aquaculture venture. However, intensive catfish cultivation deteriorates water quality rapidly, leading to diseases and stress for the fish. We explored the possibility of integrating high density monoculture of *Heteropneustes fossilis*, locally known as *singhi*, and edible aquatic medicinal plants in floating rafts as an environmentally sustainable solution. The experiments were performed in a small cemented tank of 1.5 m x 1.0 m x 1.0 m dimensions containing water to a depth of 0.2-0.3 m for a period of 6 months. No water exchange was performed during the period. Fingerlings of *singhi* (2 g body weight) were introduced into tank at a stocking density of 46 numbers/ m^2. The fish were fed with commercial pellet feed containing 30% crude protein, twice a day. Feeding was performed initially at 5% body weight and subsequently tapered to 2% body weight. A floating raft of 60 cm x 60 cm x 6 cm size made up of GI mesh and plastic bottles and containing alternating layers of soil and coco peat, was used for cultivating edible aquatic medicinal plants- *Enhydra fluctans* and *Hygrophila spinosa*. Six plantlets were planted in each raft. The plants were watered and maintained under gentle sun and allowed to establish roots for around 5 days after which they were shifted into the tank. At the end of the culture period, fish were harvested by dewatering the tank. In spite of maintaining the system without external aeration or water exchange, 1.5-2.5 kg fish (mean individual weight of 40 ± 10 g; with 85-90% survival) could be harvested per cycle. Additionally, weekly harvest of 500-600 g aquatic plants was also realized. This system can be replicated in both rural as well as urban areas. Based on the study, it could be suggested that integration of aquatic medicinal plants with intensive catfish culture could be a sustainable aquaculture strategy for added economic profitability while being ecologically sustainable.

Keywords: Air breathing fish, catfish, inorganic waste, monoculture, profitability

O/2.04

Performance of Bush Pepper (*Piper nigrum* L.) Cuttings on Different Potting Media

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Performance of bush pepper (*Piper nigrum* L.) cuttings on different potting media combinations was studied. These combinations included T_1 – Soil + FYM (3:1), T_2 - Soil + FYM + Vermicompost (1:1:1), T_3 - Soil + FYM + Cocopeat (1:1:1), T_4 - Soil + FYM + Rice husk (1:1:1), T_5 - Soil + FYM + Sand (1:1:1), T_6 - Soil + Vermicompost + Sand (1:1:1), T_7 -Soil + Vermicompost + Cocopeat (1:1:1) and T_8 - Soil + Vermicompost + Rice husk (1:1:1). The experiment was conducted in randomized block design with three replications. Treatments were assessed based on parameters such as survival percentage, days required for initiation of sprouting, days required for completion of sprouting, number of leaves, leaf area, number of sprouts, length of sprouts, dry weight of shoot, dry weight of roots, length of root, shoot to root ratio, absolute growth rate and relative growth rate. The results revealed that treatment T_2 performed the best in terms of sprouting (92.00%), survival of cuttings (61.67%), days required for initiation of sprouting (68.33), number of leaves (4.74), leaf area (1711.23 mm^2), number of sprouts (8.00), length of sprouts (8.17 cm), weight of shoot (5.37 g), dry weight of roots (2.30 g), length of root (40.29 cm), shoot root ratio (2.33) and relative growth rate (0.911 cm/cm/day). On the other hand, the maximum shoot to root ratio (length basis) (0.211), the highest absolute growth rate (0.0814 cm/day) and the highest B:C ratio (1.98) was registered in treatment T_5 (Soil: FYM: Sand :: 1:1:1).

Keywords: Absolute growth rate, relative growth rate, sprouting, substrate

O/2.05

Studies on Application of Organic Nutrients on Survival and Growth of Black Pepper Cuttings (*Piper nigrum* L.)

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The present investigation was undertaken during the year 2020-2021 in randomized block design with three replications and ten treatments *i.e.* T_1 - Vermiwash (10%) drenching, T_2 -Vermiwash (15%) drenching, T_3 - Vermiwash (20%) drenching, T_4 - Cow urine (2.5%) drenching, T_5 - Cow urine (5%) drenching, T_6 - Cow urine (7.5%) drenching, T_7 - Humic acid (0.1%) drenching, T_8 - Humic acid (0.2%) drenching, T_9 - Humic acid (0.3%) drenching and T_{10} - Control. During the investigation, uniform package of practices was followed for all the treatments including control. Various growth parameters *viz.*, number of days to sprout, sprouting percentage, number of leaves, length of shoots (cm), girth of plant (mm), leaf area (cm^2), absolute growth rate (cm/day), relative growth rate (cm/cm/day), root length (cm), survival percentage, shoot dry weight (g) and root dry weight (g) were recorded at 180 days after planting of cuttings. Among the different treatments studied, the treatment T_6 (Cow urine (7.5%) drenching) recorded the highest survival percentage (88%), less number of days taken for initiation of sprouting (19.33 d), peak sprouting (40.60 d) and last sprouting (47.07

d), maximum shoot length (87.97 cm), number of leaves (13.17), girth of cutting (7.55 mm), leaf area (68.93 cm^2), root length (18.82 cm), dry root weight (3.99 g), dry shoot weight (35.60 g), absolute growth rate (0.88 cm/day), relative growth rate (0.0055 cm/cm/day) and the maximum net returns (Rs. 484.38) with higher benefit: cost ratio (1.79) was recorded to be the best treatment, while the lowest values for these parameters were observed under control (T_{10}). On the basis of results obtained from the present investigation, it could be concluded that the drenching of cow urine (7.5%) at monthly intervals from the planting of black pepper cuttings was beneficial for getting early sprouting, rapid growth and high survival percentage with maximum net returns and B: C ratio.

Keywords: Drenching, cow urine, humic acid, net returns, propagation, vermiwash

O/2.06

Black pepper based mixed cropping system for sustainable productivity and food security

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Black pepper (*Piper nigrum* L.) is called the King of Spice or the Black Gold. Apart from its various medicinal properties, it is widely used for culinary purposes, especially for the growing industrialized food economies. However, by virtue of its perennial nature, the initial establishment of pepper plantation presents many problems to farmers. Newly planted gardens are subject to erosion and heavy weed growth requires lot of manpower. To make black pepper production systems more efficient, cultivation of intercrops in juvenile black pepper gardens would be remunerative. Hence, in the present study, black pepper based mixed cropping systems were established involving colocasia, elephant foot yam, sweet potato (white and red types) and mango ginger. The economic produce was harvested and the yield was quantified for per hectare of black pepper garden and cost of cultivation was worked out. Highest benefit cost ratio was found in black pepper + elephant foot yam (1.72), closely followed by black pepper + mango ginger (1.63) and the lowest ratio was recorded in black pepper as monocrop (0.44). Thus, considering sustainable agriculture in the global context, black pepper based mixed cropping system was found to be beneficial.

Keywords: Black pepper, economical, intercropping, sustainable, tuber crops

O/2.07

Feasibility of Intercropping Annual Oilseed Crops with Medicinal and Aromatic Plants for Economic Prosperity and Sustainability

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In the rainfed ecosystem, where majority of annual oilseed crops are cultivated, intercropping is biologically more dynamic than the sole cropping as it ensures yield stability of at least one crop and fetches better returns to the farmers besides improving soil fertility, cropping intensity and resource use efficiency. Medicinal and aromatic plants (MAPs) are looked upon not only as a source of affordable health care products but also as a source of income. Since cultivation of MAPs on lands that are presently being utilized for

producing food/pulses/oilseed crops is neither advisable nor justified, their proper integration into the existing cropping systems as complementary rather than supplementary systems is more desirable. Intercropping of sunflower with medicinal crop like ashwagandha at 1:6 or 1:7 ratio with 100% seed rate of ashwagandha was found more sustainable, economically remunerative and more productive. The intercropped sunflower recorded a sunflower equivalent yield (SEY) of 2.60 t/ha, which was reduced to 96% (1.33 t/ha) in the sole crop of sunflower. Sunflower intercropped with 100% seed rate of ashwagandha recorded significantly higher dry root yield (578 kg/ha). Integration of MAPs through overlapping cropping systems involving oil seed crops *viz.*, (lemongrass + basil) + linseed; (vetiver + basil) + linseed; (palmarosa + basil) + linseed and sunflower + red gram + clusterbean/greengram : geranium (2:1) resulted in higher cropping intensity, best use of residual soil moisture and nutrients especially phosphorus and additional employment generation. Need-specific and area-specific remunerative systems based on MAPs and new oilseed crop models should be developed through research and development. These new paradigms will not only provide extra returns to the farmers without disturbing the food nutritional security but would also provide an attractive alternative for land and resource usage optimization.

Keywords: Ashwagandha, geranium, lemongrass, linseed, palmarosa, sunflower, vetiver

O/2.08

Problems and Prospects of Spices Cultivation in the Western Ghats in Karnataka

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The Western Ghats (*Malanad*) region of Karnataka has suitable climate and soil conditions for growing major spice crops *i.e.* black pepper, cardamom, ginger, clove and nutmeg. Black pepper is grown in coffee and areca nut plantations in Kodagu, Chikkamagaluru, Hassan, Uttar Kannada, Dakshina Kannada, Udupi and Shivamogga districts of the state. In the recent years, black pepper is being grown in areca nut plantations in non-traditional areas also. Cardamom is grown in Kodagu, Hassan, Chikmaglore and Uttar Kannada districts, while nutmeg and clove are grown in Dakshina Kannada, Udupi, Uttar Kannada and Shivamogga. Karnataka has overtaken Kerala in black pepper production and has become the country's leading pepper producer, accounting for 45% of the total production. While Karnataka produced 33,000 MT of black pepper in 2014-15 against Kerala's 28,000 MT, the margin widened in 2021-22, when Karnataka produced 39,000 MT black pepper as against 21,000 MT by Kerala. Increased area and production of black pepper in Karnataka is due to adoption of improved production technology developed and transferred by ICAR-Indian Institute of Spices Research, Kozhikode and its Regional Station, Appangala, Kodagu, Karnataka. Many success stories on impact of basin irrigation and shade regulation, integrated nutrient management, pest and disease management in black pepper have been documented. Few pepper growers were harvesting 5-50 tonnes based an area of cultivation in coffee and areca nut based cropping systems. Cardamom is grown in about 25,135 ha and production is around 697 t (2021-22). Area under ginger is 45,048 ha in Karnataka with production of 5,65,561 t (2021-22). Nutmeg, clove and vanilla are grown in areca nut based cropping systems in Karnataka in limited area. Production constraints in spices involve lack of availability of quality planting material, erratic rainfall and pest and disease incidence. Success stories related to black pepper, cardamom, ginger, nutmeg, clove and vanilla will be discussed in detail.

Keywords: Black pepper, cropping systems, production technology, success story

O/2.09

Performance of Coriander in Vertical Farming System under Island Condition

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In Andaman and Nicobar Islands, leafy coriander is not cultivated commercially due to high rainfall and relative humidity conditions and hence the entire demand is met from its import from the mainland India. Due to higher demand and limited supply, coriander leaves are sold at very high prices (Rs. 400/- to 600/- per kg) in the local markets. In view of this, Dweep Vertigrow, a vertical farming model for growing leafy vegetables in kitchen/terrace garden was developed at ICAR-CIARI, Port Blair with a floor coverage of 5.0 m^2 (2.0 m x 2.5 m) and 2.5 m height. The model can accommodate 100 pots (4" size) with one tray (2 m^2) in between the vertical frames, which are filled with soilless growing media. The structure is covered with UV stabilized polythene sheet for protecting the crop from rainfall and high solar radiation. There is provision for collection of the drained out nutrient solution for recirculation. The light intensity in the structure ranged from 8,680 lux (3:00 pm) to 35,600 lux (11:00 am) and the harvested rainwater supplemented the water requirement. From the system, biomass yield of 7-8 kg of coriander (Arka Isha) could be harvested in 60 days (first cut at 40 days and second cut after 20 days of first cut). Hence, in one year, a total biomass yield of 35-40 kg of coriander could be obtained from one unit. As the nutrient solution containing all the essential nutrients was used, the quality of produce was superior. Coriander leaves recorded higher TSS (5.3 °Brix), ascorbic acid content (160 mg/100 g) and total chlorophyll content. Other leafy vegetables such as spinach, mint and lettuce also performed well under soilless cultivation in the structure. Thus, the vertical farming system with soilless media was found to be highly beneficial for round the year cultivation of coriander and other leafy vegetables under island condition in the kitchen/terrace garden or vacant spaces in urban residential areas.

Keywords: Dweep Vertigrow, nutrient recycling, soilless media, water harvesting

O/2.10

Studies on Fertigation and Bio-stimulants in Turmeric (*Curcuma longa* L.) under Raichur, Karnataka Conditions

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Turmeric (*Curcuma longa* L.) is an important medicinal and spice crop. The rhizomes and its powder have been used extensively in the Indian Systems of Medicine (Ayurveda, Unani and Siddha) for its antioxidant, anti-inflammatory, hypoglycemic, antimicrobial, antiviral, and anti-cancer properties. As the crop requires assured irrigation for its growth and yield, drip irrigation and fertigation are viable alternatives to improve the efficiency of productions system. Keeping this in view, the present experiment was conducted during the Kharif season of 2022-23 at Main Agricultural Research Station, Department of Horticulture, University of Agricultural Sciences, Raichur, Karnataka. The experiment was laid out in a split plot design with three replications. Recommended dose of fertilizers (RDF) provided for the crop was 150 Kg N, 125 Kg

P_2O_5, and 250 Kg K_2O ha^{-1}. The treatments in the experiment consisted of 100% RDF through water soluble fertilizers (WSF), 75% RDF through WSF, 50% RDF through WSF, and RDF through soil application as main plots and bio-stimulants *i.e.* humic acid @ 0.3%, vermiwash @ 5%, and water spray as sub plots. The results revealed that the combination of 75% RDF through fertigation along with foliar spray of humic acid @ 0.3% recorded the maximum plant height (51.56 cm), number of tillers per clump (7.67), number of leaves per clump (15.95), leaf area per clump (2907.52 cm^2), leaf area index (2.15), chlorophyll content (54.64) and fresh rhizome yield (31.02 t ha^{-1}). The B: C ratio was the highest (3.31) in plants supplied with 75% RDF through fertigation. Hence, the present study suggested that the combination of fertigation with 75% RDF through WSF along with a foliar spray of humic acid @ 0.3% is profitable for turmeric growers in Raichur, Karnataka.

Keywords: Humic acid, irrigation, vermiwash, water soluble fertilizers

O/2.11

Enhancement of Cropping System's Productivity with Spices and Medicinal Plants in Grown-up Oil Palm Plantations

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Oil palm (*Elaeis guineensis* Jacq) is a highest vegetable oil yielding (4-6t/ha) crop and grown to an extent of 4.00 lakh hectares in India. Owing to frequent price fluctuations and high cost of labour, there is a great need for inter cropping in mature oil palm plantations to enhance system' productivity and farmers' income. Further, the major constraint of grown-up oil palm plantations is poor incidence of light (<30%) which restricts the choice of crops for inter cropping. Keeping in view an existing situation of oil palm plantations, evaluated the performance of spice and medicinal plants *i.e.*, turmeric, mango ginger, black turmeric, white turmeric, wild turmeric, Indian arrow root, ginger, red ginger, black ginger, galanga and bitter ginger in oil palm plantation for three years. Studies revealed that mango ginger (15.36 t), wild turmeric (8.22 t), Indian arrow root (7.85 t), white turmeric (7.12 t), turmeric (6.85 t) and ginger (6.84 t) recorded good yield as compared to turmeric (5.56 t), bitter ginger (3.92 t), red ginger (3.00 t), galanga (2.10 t) and black ginger (1.82 t). Average light infiltration in inter cropped area of the plantation was 276µ moles/m^2/sec or 23.78%. Quality parameters like volatile oil, oleoresin and curcumin content were estimated in the crops. Among the crops, maximum volatile oil (3.00%) and oleoresin (16.60%) levels were recorded in turmeric. Curcumin content recorded in turmeric was 3.46%. Chlorophyll content in leaves was higher in ginger (3.45 mg g^{-1}) whereas lower chlorophyll was noticed in red ginger (1.02 mg g^{-1}). Gas exchange parameters such as photosynthesis rate, transpiration rate, stomatal conductance and intercellular CO_2 concentration were recorded for all the crops. Based on the results and cost benefit analysis, crops like mango ginger, turmeric, ginger, Indian arrow root, white turmeric, wild turmeric and black turmeric were identified as suitable intercrops for grown up oil palm plantations.

Keywords: Gas exchange, intercrops, photosynthesis, rhizomatous

Theme 2: Sustainable Production Technologies for Spices and MAPs

Poster Presentations

P/2.01

Growth and Yield Performance of Turmeric (*Curcuma longa* L.) Varieties to Different Spacings in Konkan Region

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The present investigation was carried out during the year 2019-20 at the College of Horticulture, Dapoli with a view to study the growth and yield performance of turmeric varieties to different spacings in Konkan region. The treatment combinations consisting of two varieties *viz*. Salem (V_1) and Waigaon (V_2) with three levels of spacing *viz*. 60 cm × 45 cm (S_1), 40 cm × 45 cm (S_2) and 40 cm × 30 cm (S_3) were tested under split plot design with seven replications. The results revealed that the variety Salem (V_1) recorded significantly higher plant height, number of leaves, leaf length, leaf width, number of tillers and leaf area at different growth and development stages and also recorded the highest values for rhizome characters *i.e.* girth of mother rhizome, girth of secondary finger, length of secondary finger, weight of mother rhizome, weight of secondary finger, nodes per mother rhizome, nodes per primary finger, nodes per secondary finger and yield attributing parameters *i.e.* yield per plant, yield per plot and yield per hectare. However, length of mother rhizome, length of primary finger, girth of the primary finger and weight of primary finger were found to be highest in the variety Waigaon. Curcumin content was also superior (5.21%) in Waigaon as compared to Salem (3.84%). Similarly, growth, yield and quality attributes of turmeric were significantly influenced due to different spacings. The highest number of leaves, leaf length, leaf width, number of tillers and leaf area were recorded in rhizomes planted at 60 cm × 45 cm spacing (S_1), while the highest plant height was found at closer spacing of 40 cm × 30 cm (S_3). The highest yield per plot (18.55 kg) and yield per hectare (34.34 t) was also recorded at 40 cm × 30 cm (S_3), while all the primary fingers, secondary fingers and mother rhizome parameters were found to be maximum at wider plant spacing (60 cm × 45 cm). The effect of different spacings had non-significant effect on the curcumin content. During the course of investigation, the interaction effect between varieties and spacings revealed that the treatment combination of V_1S_1 (Salem variety planted at 60 cm × 45 cm) recorded significantly higher number of leaves, leaf length, leaf width, number of tillers and leaf area over the rest of treatment combinations. The mother rhizome characteristics, primary finger characteristics, secondary finger characteristics and yield per plant were also recorded to be significantly better in same treatment combination. However, significantly highest plant height (83.22 cm), yield per plot (20.30 kg) and yield per hectare (37.59 t) were recorded in treatment combination V_1S_3 (Salem variety planted at 40 × 30 cm). Curcumin content was not significantly influenced by the interaction effect. Hence, it could be concluded that for securing higher yield per hectare under the Konkan region, it was advisable to grow turmeric variety Salem at closer spacing of 40 cm × 30 cm.

Keywords: Curcumin, finger, quality, Salem, yield, Waigaon

P/2.02

Influence of GA_3 Treatment and Growing Media on Seed Germination and Seedling Vigour Parameters of Tamarind (*Tamarindus indica* L.)

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A field experiment on studying the influence of seed treatment and growing media on germinability and seedling vigour of tamarind (*Tamarindus indica* L.) was carried out at the Fruit Research Station, Imaliya, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during 2021–22. The experiment consisted of twenty treatment combinations with different concentration of GA_3 and growing medium in AFRBD. Seed treatment with GA_3 and different growth media showed significant effect on seed germination and seedling growth parameters. However, the interaction of seed treatment (200 mg/L GA_3) and growing media (soil + vermicompost + Biofertisol) was found to be the most efficient with respect to all the seed germination and growth parameters. Days taken to first germination, days taken to 50% germination, growth parameters *viz*. seedling height at 30, 60, 90 and 120 days after sowing (DAS), number of leaves per seedling and stem girth at 30, 60 and 90 DAS, length of the root, fresh shoot weight, dry shoot weight, fresh root weight, dry root weight, leaf area, seedling vigour index, seedling vigour index II and survival percentage at 120 days after sowing were also found to be significantly superior in this treatment combination.

Keywords: Biofertisol, germination, growing media, vermicompost

P/2.03

Assessment of Biostimulants on Performance of Velvet Bean (*Mucuna pruriens* L.)

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Biostimulants have been commercially used to promote plant growth, yield and quality of horticulture crops. Limited studies are available on application of bio-stimulants in medicinal crop production. Therefore, the present research was conducted to assess the effect of bio-stimulants on performance of velvet bean (*Mucuna pruriens* L.). Velvet bean is an annual climber with rich source of L-DOPA, which can be potentially used to treat Parkinson's disease and hypertension. The experiment was carried out at ICAR- Krishi Vigyan Kendra, Hadonahalli, Bengaluru Rural during Kharif 2021 with nine treatments replicated thrice. Effect of soil and foliar application of four different bio-stimulants *viz*., humic acid (3 ml/L), amino acid (3 ml/L), sea weed extract (1 ml/L) and microbial consortia (10 ml/L) was assessed in velvet bean. Results indicated that the application of recommended dose of fertilizers (RDF) along with foliar application of humic acid based bio-stimulant recorded maximum plant height (315.77 cm), number of leaves (105.68), leaf area index (5.22), fresh biomass (101.02 q/ha), number of inflorescence per plant (11.01), number of pods per inflorescence (14.02), number of seeds per pod (6.52), husk to seed ratio (1.65), protein content (31.94%) and L-DOPA

content (5.52%). This combination could be recommended for commercial cultivation of velvet bean to increase growth, yield and quality apart from reducing the dependence on chemical fertilizers.

Keywords: Foliar application, humic acid, L-DOPA, medicinal plants

P/2.04

Protocol for Cost-effective and Rapid Propagation of Quality Planting Material of *Gloriosa superba* L.

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A cost-effective protocol for the generation of seed propagated planting material of *Gloriosa superba* was standardized. Experiments were conducted to optimize seed germination efficiency of glory lily using hot water treatment along with different chemicals (Thiourea, KNO_3) and growth regulators (GA_3) in varying concentrations. Hot water treatment resulted in highest seed germination (65.93%), early germination (46.18 days) along with increased shoot length (11.17 cm), root length (6.89 cm) and seedling vigour index (1189.24). Hot water treated seeds also resulted in micro tubers of maximum length (2.83 cm), breadth (3.33 cm), fresh weight (2.84 g) and dry weight (0.93 g). From seeds, first, second and third generation of micro tubers were produced in 5, 8 and 11 months, respectively. Micro sized (2-3 g), medium sized (15-18 g) and plantable sized (40-50 g) tubers were produced in three consecutive seasons through the processes of dormancy and bulking alternatively. The performance of third generation micro tubers was compared with that of conventionally produced tubers in the farmer's field. Fresh seed yield of tubers obtained from routine practices adopted by farmers was 75.10 g/plant, while the micro tubers produced 87.60 g seeds/plant, which was 18.70% increase over the conventional practice.

Keywords: Cost economics, germination, Glory lily, micro tubers, seed

P/2.05

Effect of Different Concentrations of Vermiwash on Rooting, Survival and Growth of Black Pepper Cuttings (*Piper nigrum* L.)

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The present experiment was conducted with six treatments and four replications in randomized block design. Different concentrations of vermiwash used were; T_1 - vermiwash (10%) drenching, T_2 - vermiwash (20%) drenching, T_3 - vermiwash (30%) drenching, T_4 -vermiwash (40%) drenching, T_5 - vermiwash (50%) drenching and T_6 - control (no drenching of vermiwash). Growth parameters, root parameters and survival of black pepper cuttings were significantly influenced by different treatments. Treatment T_4 (40% vermiwash drenching) performed the best for survival (88.50%), days required for first sprouting (18.90), days required for peak sprouting (38.20), days required for last sprouting (49.20), sprout height (93.00 cm), number of leaves per cutting (13.05), leaf area (71.89 cm^2), thickness of the sprout (4.92 mm), number of primary roots (21.20), length of the root (20.37 cm), dry root weight (2.014 g) and dry shoot weight (8.30 g), while

cuttings in control performed the worst for these parameters. Overall, it could be concluded that vermiwash drenching gave more success, survival, and better growth of black pepper cuttings and 40% vermiwash drenching performed the best among all the treatments.

Keywords: Propagation, sprouting, stem cuttings, organic

P/2.06

Effect of Potting Media on Growth of Softwood Grafts of Nutmeg (*Myristica fragrans* Houtt.)

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The present investigation was conducted at College of Agriculture, Dr. B.S.K.K.V., Dapoli, Maharashtra. The experiment was executed in randomized block design with six treatments and four replications. The treatments included T_1 - soil + FYM + sand (2:1:1) (Control), T_2 - soil +FYM+ sand (2:1:1) with 1" top layer of coco peat, T_3 - soil + vermicompost + sand (2:1:1) with 1" top layer of coco peat, T_4 - soil + FYM+ vermicompost + sand (1:1:1:1) with 1" top layer of coco peat, T_5 - soil + FYM+ vermicompost + rice husk (1:1:1:1) with 1" top layer of coco peat and T_6 - soil + FYM+ vermicompost + cocopeat (1:1:1:1). Results revealed that the potting media composition had significant effect on growth and survival of nutmeg soft wood grafts. The maximum plant height (43.87 cm), girth (6.95 mm), shoots (2.05), internodal length (3.83 cm), root length (39.80 cm), fresh weight of root (14.40 g), dry weight of root (5.80 g), absolute growth rate (0.0646 cm/day) and survival percentage (82.00%) were recorded in treatment T_5. Grafts grown on this media gave the highest net return (Rs. 4,815.80) with benefit cost ratio of 1.64. Hence, the potting media containing soil + FYM+ vermicompost + rice husk (1:1:1:1) with 1" top layer of coco peat was found to be most suitable media for nursery raising of softwood grafts of nutmeg.

Keywords: Coco peat, nursery raising, potting, rice husk, vermicompost

P/2.07

Performance of Medicinal Plants Grown as Intercrops in Arecanut Plantation

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Arecanut (*Areca catechu* L.) is a highly profitable plantation crop that provides ample scope for cultivation of various annual, biennial and perennial crops including some medicinal and aromatic plants (MAPs) in its interspaces. Cultivation of MAPs as intercrops in arecanut based intercropping system has several advantages like higher net returns per unit area, lower incidence of pests and diseases, improvement of degraded and marginal soils, longer shelf life of their end products and foreign exchange earning potential. With this concept, a field experiment was carried out in 5-years-old bearing arecanut (cv. Mohitnagar) plantation. The experiment was laid out in randomized block design with seven treatments and three replications. These treatments included T_1: arecanut + turmeric, T_2: arecanut + black turmeric, T_3: arecanut + kalmegh,

T_4: arecanut + ashwagandha, T_5: arecanut + sarpagandha, T_6: arecanut + tulsi and T_7: sole arecanut. The study envisaged that adoption of different arecanut based intercropping systems was effective in bringing improvement in physico-chemical properties of soil. Among different intercropping systems, arecanut + sarpagandha intercropping system (T_5) resulted in significant improvement in soil physico-chemical properties like EC (34.0 dS/m), water holding capacity (38.70%), organic carbon content (0.46%), available nitrogen (269.28 kg/ha), available phosphorus (70.53 kg/ha), available potassium (188.65 kg/ha) in the soil as well as higher growth, land equivalent ratio (2.25) and chali yield of arecanut (3.91 kg/palm). However, economic analysis of various systems indicated that arecanut + black turmeric intercropping system (T_2) was the most remunerative one with highest arecanut equivalent yield (135.90 q/ha), net returns (Rs. 8,00,992/- per ha) and benefit-cost ratio (2.43) followed by arecanut + sarpagandha intercropping system (T_5).

Keywords: Benefit cost ratio, cropping system, intercropping, medicinal and aromatic plants

P/2.08

Impact of Water Stress on Physiological Performance, Secondary Metabolites, and Gene Expression in Kalmegh (*Andrographis paniculata*)

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Andrographis paniculata, commonly known as kalmegh, holds a significant position in traditional medicine, particularly in India, China, and Thailand. It boasts a spectrum of medicinal properties, including anticancer, antidiabetic, anti-HIV, antibacterial, anti-malarial, anti-inflammatory, anti-angiogenic, hepatoprotective, and cardioprotective activities. These properties are attributed to its diterpene lactone compounds such as andrographolide, 14-deoxyandrographolide, neoandrographolide, and andrograpanin. The present study aimed to explore the impact of water stress on the accumulation of bioactive compounds in *A. paniculata*. For this, a pot experiment was carried out to identify the right stage of plant growth for stress imposition to enhance the contents of bioactive compounds. Plants of different stages (vegetative, flowering and fruiting) were used for water stress imposition. The stressed, stress recovered and control plants were harvested and four terpenoid compounds were analyzed. Flowering stage was found to be the best for stress imposition to get better bioactive compound recovery. Andrographolide content could be increased by 40-50% though water stress imposition. Stress recovery resulted in decline in the metabolic content of secondary metabolites to the level of control. Effect of water stress on different physiological and biochemical parameters was also studied. Significant differences were observed for various physiological and biochemical parameters like photosynthesis rate, stomatal conductance, transpiration rate, relative water content, plant biomass, chlorophyll content, MDA content, proline content and various antioxidant enzyme activities. Furthermore, the study delved into the expression profiling of pivotal genes involved in the andrographolide biosynthetic pathway, specifically HMGR and GGPS. Both genes exhibited heightened expression under stress conditions compared to the control group. In conclusion, water deficit stress emerges as a promising strategy for enhancing the production of bioactive compounds in kalmegh. This research sheds light on the potential utility of controlled water stress as a means to enrich the therapeutic components of this medicinal plant.

Keywords: Andrographolide, gene expression, metabolite, stress

P/2.09

Influence of Foliar Application of Micronutrients on Growth, Yield and Quality of Ajwain (*Trachyspermum ammi* L.)

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Ajwain (*Trachyspermum ammi* L.), also known as carom seed, Bishop's weed and omam is an aromatic-herbaceous plant that belongs to the family Apiaceae and is grown as an annual crop in many countries including Egypt, Iraq, Iran, and India. The roots of ajwain are diuretic in nature, while the seeds are highly aphrodisiac. Seeds contain between 2.0-4.4 per cent brown oil known as ajwain oil. A field experiment was conducted at PSMAC Research Block, College of Horticulture, Bengaluru during Rabi season 2022-2023 to study the influence of foliar application of micronutrients on growth, yield and quality of ajwain variety AA-93. The experiment was laid out in randomized complete block design comprising of 15 treatments (T_1 - control, T_2 - $ZnSO_4$ (0.5%) at 45 DAS, T_3 - $ZnSO_4$ (0.5%) at 45 and 60 DAS, T_4 - $FeSO_4$ (0.5%) at 45 DAS, T_5 - $FeSO_4$ (0.5%) at 45 and 60 DAS, T_6 - $CuSO_4$ (0.5%) at 45 DAS , T_7 - $CuSO_4$ (0.5%) at 45 and 60 DAS, T_8 - $MnSO_4$ (0.5%) at 45 DAS, T_9 - $MnSO_4$ (0.5%) at 45 and 60 DAS, T_{10} - Borax (0.2%) at 45 DAS, T_{11} - Borax (0.2%) at 45 and 60 DAS, T_{12} - ammonium molybdate (0.1%) at 45 DAS, T_{13} - ammonium molybdate (0.1%) at 45 and 60 DAS and T_{14} – 0.5% each of $ZnSO_4$, $FeSO_4$, $CuSO_4$, $MnSO_4$ + 0.2% Borax + 0.1% ammonium molybdate at 45 DAS, T_{15}-0.5% $ZnSO_4$, $FeSO_4$, $CuSO_4$, $MnSO_4$ + 0.2% Borax + 0.1% ammonium molybdate at 45 and 60 DAS), that were replicated twice. Among all the treatments, T_{15} showed significantly highest plant height (75.76 cm), number of primary and secondary branches (12.2 and 46.20, respectively), number of umbels plant^{-1} (84.20), seed yield ha^{-1} (818 kg), chlorophyll content (2.12 mgg^{-1}) and essential oil content (3.25%). Minimum plant height, seed yield, and oil percentage were recorded in control. It was due to the presence of all the micronutrients required for plant growth and development in treatment 15, that the plants in this treatment resulted in higher yield and quality. These micronutrients are involved in essential processes of plant system including nutrient uptake and several metabolic processes.

Keywords: Carom seeds, essential oil, micronutrients, nutrient spray, seed yield

P/2.10

Effect of Potting Media and Inorganic Fertilizers on Growth and Yield of Bush Pepper

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Black pepper (*Piper nigrum* L.), christened as the King of Spices and the Black Gold, is the most important and widely used spice in the world, which originated from the tropical evergreen forests of the Western Ghats. Bush pepper raised from the plagiotropic shoots of black pepper grown in pots is gaining momentum in urban horticulture. Traditional potting mixture of soil, sand and farmyard manure (FYM) needs to be replaced due to less availability of sand. Moreover, the medium needs to be supplemented with fertilizers for increased growth and yield. The pot culture experiment was carried out at the Instructional Farm of College of Agriculture, Vellayani during 2017-18. Rooted cuttings of bush pepper hybrid Panniyur-

1 were used. The experiment was laid out in completely randomized block design with three types of potting media, five inorganic fertilizers and a control. The results of the study indicated that growing bush pepper in potting medium containing soil + FYM + vermicompost + coir pith compost (3:3:1:1) with the application of inorganic fertilizers @ 25.0: 25.0: 50.0 g of NPK per plant per year in split doses at quarterly intervals improved plant growth parameters including plant height, number of secondary branches and number of leaves besides yield parameters such as number of spikes per plant (32.67), fresh and dry weight of berries per plant (199.49 g/plant and 70.92 g/plant, respectively).

Keywords: Berries, coir pith compost, growth, spike, vermicompost, yield

P/2.11

Studies on Agro-ecology, Economic and Environmental Aspects of Indigenous *Allium hookeri* Thwaites- a Perennial Green Leafy Herbal Spice of Manipur

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Allium hookeri Thwaites is a perennial green leafy herbal spice, which is restricted to backyard cultivation in households of Manipur. The herb has been traditionally used to cure inflammatory diseases, high blood pressure, colitis and diabetes. Dietary lignin content in the herb ranges from 0.231 to 0.258 mg g^{-1}. To improve its commercialization prospects, its inclusion in the existing cropping systems would be advisable. Experimental inclusion of the herb in the mixed cropping systems included rotational model of chilli (8 q/ha)/radish (150 q/h)/ turnip (200 q/ha) from June to September; French bean (45 q/ha)/pea (80 q/ha)/tomato (200 q/ha)/cauliflower (120 q/ha)/cabbage (160 q/ha) from October to January and okra (100 q/ha)/spinach (100 q/ha)/bitter gourd (100 q/ha) from February to June. An additional yield of fresh, green, leafy *A. hookeri* to the tune of 50 - 70 q/ha/harvest was also achieved with an income of Rs 2.5 lakh/ha/harvest at the current market price. This system not only utilized a native plant species but also helped in improving the aesthetic value of the landscapes, increasing economic level of the growers and supplementing health care throughout the year.

Keywords: Dietary lignin, ethno-medicine, perennial, sustainable

P/2.12

Hydroponics: a Way Forward to Sustainable Production of Saffron

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Saffron (*Crocus sativus*) is a perennial, geophytic plant belonging to the family Iridaceae and produces globular underground corms. It is a valuable spice, which has been under cultivation for more than 3,500 years. The name “saffron” is derived from the Arabic word *za-faran*, which means “yellow”. Stigma is the economic part of saffron and is used for various purposes *viz*., coloring, flavoring and therapeutic *etc*. Each

saffron flower possesses three stigmas producing about 5 mg of dried produce *i.e.* saffron of commerce. Around 150,000-200,000 flowers of saffron make up 1 kg of saffron. Though it is a precious crop of great commercial importance, several constraints are faced during its cultivation. These include limited farmlands, which are located at higher altitudes under cold climate along with labour-intensive harvesting and handling practices, making it the most expensive spice in the world. Low multiplication of cormlets, fungal infections, use of traditional agronomic techniques decrease the productivity of saffron. Controlled systems of cultivation can replace the traditional saffron production systems along with disease-free corm production for making the venture more efficient. Thus, production of saffron in hydroponic systems could be a novel and economical method as growth of plants and application of nutrition medium are both controlled, thereby giving better yield and quality. Hydroponics is a reliable alternative to saffron production under open conditions. It increases the yield of saffron in a cost-effective manner. Furthermore, it has tremendous potential for sustainable production of saffron by providing disease-free stock corms. Research on developing saffron specific hydroponics system and optimization of growth conditions is envisaged.

Keywords: Corm, disease-free, stigma, sustainable

P/2.13

Effect of Foliar Application of Different Bio-stimulants on Yield and Quality Traits of Chilli (*Capsicum annum* var. *annuum*) var. Rudra

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Red chilli (*Capsicum annuum*) is a major commercial spice grown in India. High quality fruit and increased yield are desired characters both for the researchers and the growers. The present work on studying the effect of foliar application of different bio-stimulants on yield and quality traits of chilli var. Rudra was carried out at Sanjeevini Vatika, Department of Horticulture, University of Agriculture Sciences, GKVK, Bengaluru during the year 2022-23. The experiment was laid out in randomized block design with nine treatments and three replications. The treatments were control (T_1), foliar spray of 5 ml/L chitosan (T_2), 1.5 ml/L *Kappaphycus alvarezii* (T_3), 10 ml/L microbial consortia (T_4), 0.5 Mm salicylic acid (T_5), 4 ml/L humic acid (T_6), 2 ml/L seaweed extract (T_7) and 5 ml/L fish amino acid (T_8) applied at 15, 30, 45, 60 and 75 days after planting. Among the biostimulants tested in the study, application of humic acid at 4ml/L showed significantly superior values for yield and quality attributes as compared to all other treatments. Yield and quality parameters such as days to 50% flowering, number of fruits per plant, fruit length (cm), fruit diameter (cm), green fruit weight (g), green fruit yield/plant (g), green fruit yield/ha (t), dry fruit weight (g), dry fruit yield/plant (g), dry fruit yield/hectare (t), TSS (˚Brix), chlorophyll (%), ascorbic acid (mg/100 g), capsaicin (%) and oleoresin content (%) were positively influenced by the treatment.

Keywords: Capsaicin, dry chilli, oleoresin, quality, yield

P/2.14

Effect of Heading Back and Floral Bud Inducer on Growth, Flower and Oil Yield in Ylang - Ylang (*Cananga odorata* (Lam.) Hook. f. & Thomson)

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The present experiment on effect of heading back and floral bud inducer on growth, flower yield and oil yield in Ylang - Ylang was conducted at Aromatic Crops Field and Quality Analytical Laboratory, Department of Horticulture, University of Agricultural Sciences, GKVK, Bengaluru during June 2021 to May 2022. The experiment was laid out in factorial completely randomized design, consisting of twelve treatments divided into two factors *i.e.*, trees headed back at 3 feet (a_0), 4 feet (a_1) & 5 feet (a_2), and no application (b_0), application of 2% KNO_3 (b_1), 3% KNO_3 (b_2) & 4% KNO_3 (b_3) as floral bud enhancer. The treatments were replicated thrice. The analysed pooled data revealed that maximum tree height (5.35 m) and number of primary branches (6.67) were recorded in treatment a_2b_2, while tree spread (30.35 m^2) & length of branches (3.02 m) in a_2b_1, number of flowers per branch (42.82) in a_1b_1, number of flowers per tree (4383.29) in a_0b_1, number of flower clusters per branch (11.11) in a_0b_2, length of green flower (8.68 cm), length of yellow flower (8.96 cm), weight of green flowers / tree (3812.31 g), weight of yellow flowers / tree (2532.65 g), and oil yield (50.5 ml) in a_0b_1. The lowest growth and yield was registered in the treatment a_0b_0. Hence, heading back combined with foliar application of potassium nitrate improved the growth, flower and essential oil yield in Ylang – Ylang.

Keywords: Aromatic plant, essential oil, KNO_3

P/2.15

Role of Agricultural Robots in Increasing the Productivity of Seed Spice Crops in India

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India is regarded as the World's Spice Capital as it plays a major role in global production, consumption and export of spices. Among the diverse spice crops cultivated in the country, 20 seed spices are cultivated which are of economic importance and find extensive use in culinary and medicinal preparations. However, despite India's impressive spice production, the sector struggles with multiple challenges in meeting the global demand for seed spices. One of the major challenges is fragile nature of plants making harvesting a cumbersome operation. Traditional harvesting methods are dependent on manual labour and are time consuming. Mechanical harvesters designed for grain crops are not suitable for delicate, short statured plants of seed spices with seed shattering habit. To solve these challenges and meet the demand for expansion of area under seed spices, it is mandatory to develop special robotic harvesters for these crops. Such innovations will increase the efficiency of harvesting, reduce the dependency on manual labour and ensure better quality of the produce thereby ensuring the profitability of the sector.

Keywords: Harvesting efficiency, mechanical harvester, robotic harvester

P/2.16

Effect of Hydrogel in Different Irrigation Intervals on Yield and Soil Attributes of Ginger (*Zingiber officinale* Rosc.) Under Southern Transition Zone of Karnataka

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A field experiment was conducted at Kademanuganahalli, Mysore during 2017-18 to study the influence of hydrogel on physiology, yield and soil attributes of ginger under different irrigation intervals. The experiment was laid out in split plot design. Three levels of irrigation (M_1= 7 days, M_2= 14 days and M_3= 21 d interval) and eight levels of Pusa hydrogel (S_1= Control, S_2= 2.0 kg/ha, S_3= 2.5 kg/ha, S_4= 3.0 kg/ha, S_5= 3.5 kg/ha, S_6= 4.0 kg/ha, S_7= 4.5 kg/ha and S_8= 5.0 kg/ha) were allocated to main plots and sub plots, respectively. Rhizomes receiving application of higher doses of hydrogel *i.e.* 5.0 kg per ha (S_8) had maximum number of primary fingers (7.01) and secondary fingers (20.63) per clump and fresh rhizome yield (31.30 t/ha), whereas the plants in control plot without hydrogel application (S_1) recorded the least number of primary fingers (4.41) and secondary fingers (15.25) per clump as well as fresh rhizome yield (23.04 t/ha). Among treatment interactions, maximum number of primary (8.20) and secondary fingers (24.36) per clump and fresh rhizome yield per ha (36.86 t) were recorded in M_2S_8 (14 d irrigation interval with 5.0 kg hydrogel/ha). The soil reaction (pH), total soluble salts content (EC) and organic carbon content did not differ significantly due to irrigation intervals, levels of hydrogel application and interaction between them.

Keywords: Fingers, physiology, rhizome, yield

P/2.17

Effect of Foliar Application of Micronutrients on Growth, Yield and Quality of Garlic under Vidarbha Conditions

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The present investigation was undertaken at the Instructional Farm, Department of Vegetable Science of the authors' institute during Rabi season of 2021-2022. The experiment was laid out in randomized block design with three replications and nine treatments involving foliar applications of T_1: $ZnSO_4$ (0.25%), T_2: $ZnSO_4$ (0.50%), T_3: $FeSO_4$ (0.25%), T_4: $FeSO_4$ (0.50%), T_5: Borax (0.2%), T_6: Borax (0.3%), T_7: PDKV Micrograde-II (1%), T_8: PDKV Micrograde-II (2%) and T_9: Control. Among all the treatments, treatment 8 *i.e.* foliar application of PDKV Micrograde-II (2%) recorded significant improvement in growth parameters of plants *viz.*, plant height (cm), length of leaves(cm), number of leaves per plant and neck thickness (cm) at 90 days after sowing as well as yield and yield contributing characters such as fresh weight of bulb (g), cured weight of bulb (g), number of cloves per bulb, length of cloves (cm), bulb girth (cm), yield per plot (kg), yield per hectare (q) and total soluble solids content (°Brix).

Keywords: Borax, $FeSO_4$, micronutrients, PDKV Micrograde-II, $ZnSO_4$

P/2.18

Effect of Different Mulches and Fertigation Scheduling on Growth, Yield and Quality of Turmeric

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A field experiment was conducted during Kharif season of 2017 and 2018 in strip plot design with three replications and two factors *i.e.* different mulches (M) *viz.* control (without mulch), soybean straw mulch and 50 micron silver polythene mulch and fertigation scheduling (F) *viz.* control (100% RDF through soil application), 10 split doses at 15 d interval through fertigation @ 80% RDF, 20 split doses at 8 d interval through fertigation @ 80% RDF, 30 split doses at 5 d interval through fertigation @ 80% RDF and 40 split doses at 4 d interval through fertigation @ 80% RDF. Among the mulching treatments, M_2 (soybean straw) and among the fertigation scheduling treatments, F_4 (30 split doses at 5 d interval through fertigation @ 80% RDF) performed the best with respect to plant growth and yield parameters as well as available soil nutrient status after harvesting and nutrient uptake by plants. Among the fifteen treatment combinations, M_2F_4 was found to be significantly superior over all the other treatment combinations.

Keywords: Foliar spray, soybean straw, recommended dose of fertilizers (RDF)

P/2.19

Effects of Plant Growth Retardant and Nutrient Levels on Ginger (*Zingiber officinale* Rosc.) in Soilless Culture

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Ginger is a major spice crop grown for its pungent rhizomes. The crop is grown at commercial scale in different parts of the country due to its wide applications. The crop is affected by several insect pests and diseases, and availability of quality planting material is a limiting factor for its cultivation. The present investigation was carried out with an objective to produce quality seed rhizomes in soilless culture under protected structure. Crops under protected structures result in profuse above ground vegetative growth. Since rhizomes are of economic concern, use of growth retardants has been proven beneficial. Coupled with it is the basic exhaustive nature of the ginger crop. Hence, an experiment was carried out using growth retardant and nutrients at various levels consisting of 12 treatment combinations in total. Soilless media used was a combination of vermicompost and sand (75:25). The treatment involving application of 180% of recommended dose of fertilizers + 180% secondary nutrients + micronutrients and chlormequat chloride @ 1000 ppm was found to be better in terms of plant growth and rhizome yield. This treatment recorded maximum number of tillers per plant (14.50), number of leaves per clump (350.87), highest essential oil content (1.40%), oleoresin content (10.20%), crude fibre content (4.70%) and maximum benefit cost ratio of 1.91. Pest and disease infestation was recorded throughout the study period, and no incidence of diseases was found. Among the insect pests, rhizome fly infestation was recorded, but it was below the economic threshold level.

Keywords: CCC, Protected cultivation, rhizome fly, soilless culture

P/2.20

Effect of Season on Propagation of Bush pepper (*Piper nigrum* L.) by Cutting

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The present investigation was carried out at the College of Horticulture, Dr. BSKKV, Dapoli with the objective to find out the optimum season for propagation of bush pepper. The experiment was laid out in randomized block design with seven treatments *i.e.* T_1- planting in January, T_2-planting in February, T_3 -planting in March, T_4-planting in April, T_5-planting in May, T_6-planting in June and T_7-planting in July and three replications. The results revealed that the highest survival percentage (55.83%), the least days required for completion of sprouting (68.83 d) and the highest number of leaves/plant (8.83) were observed in treatment T_6 i.e. planting in June. Significantly highest leaf area (1594.97 mm^2) at 180 days after planting, number of sprouts (8.80 length of sprouts (21.99 cm), dry weight of shoot (8.59 g), dry weight of roots (1.96 g), length of root (42.08 cm), shoot root ratio (4.39), absolute growth rate (0.189 cm/day), relative growth rate (1.338 cm/day) and B:C ratio (1.71) were also recorded in the same treatment *i.e.*, planting in June. However, the minimum days required for initiation of sprouting (28.33) were observed in $T_{4.}$ *i.e.*, planting in April.

Keywords: Black pepper, relative growth rate, rooting, sprouting

P/2.21

Studies on Rapid Multiplication Methods in Black Pepper (*Piper nigrum* L.)

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The present investigation was conducted during 2021-22 to evaluate rapid multiplication methods for propagation of black pepper (*Piper nigrum* L.)" variety Panniyur-1 and to study the growth of saplings obtained from different methods in nursery. The experimental design used was randomized block design with seven treatments and four replications. The treatments comprised of seven rapid multiplication methods *viz*., T_1–raised bed (control), T_2–split halves of PVC, T_3–serpentine, t_4–soil mound, T_5– wooden log, T_6–modified serpentine and T_7–wire mesh column. Among the methods studied, modified serpentine method (T_6) recorded the highest number of cuttings per harvest, total number of cuttings obtained per year, sprouting percentage (%), survival percentage (%), number of leaves, leaf area (cm^2), girth of sprout at collar (mm), sprout length (cm), number of nodes, inter-nodal length (cm), fresh shoot weight (g), dry shoot weight (g), absolute growth rate, relative growth rate, number of roots, length of longest root (cm) of rooted cuttings, fresh root weight (g), dry root weight (g) and was found to be the best followed by serpentine method. As far as growth performance, quality and production of total number of saplings per year are concerned, modified serpentine method followed by serpentine method performed the best. However, economic analysis of the treatment (per 1000 number of saplings) revealed that the highest net returns and B:C ratio were obtained in serpentine method (T_3) and hence, serpentine method was found to be the most economically feasible method for rapid propagation of black pepper.

Keywords: Black pepper, modified serpentine method, net returns, rapid multiplication

P/2.22

Response of Asalio (*Lepidium sativum*) to Different Sowing Windows and Land Configuration

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This research paper deals with investigating the influence of sowing windows and land configuration on growth and yield of asalio (*Lepidium sativum*), a locally significant crop. The study was conducted at the AICRP on Medicinal, Aromatic Plants and Betelvine, Dr. PDKV, Akola, during the Rabi season of 2016-17 on vertisols. The experimental design employed was a split-plot design with three replications. The main plot treatments comprised of five sowing windows starting from 42nd meteorological week (MW) (15th to 21st Oct.), 43rd MW (22nd to 28th Oct.), 44th MW (29th Oct. to 4th Nov.), 45th MW (5th to 11th Nov.) and 46th MW (12th to 18th Nov.) and three land configurations of 30 cm × 10 cm, 30 cm × 15 cm and 45 cm × 10 cm, respectively. The variety employed was a local strain of asalio. The findings of the research highlighted that the sowing of asalio during the 44th MW at 30 cm × 10 cm spacing demonstrated significantly superior results in terms of grain yield (711 kg/ha), gross monetary return (Rs. 42,659 /ha), net monetary return (Rs. 25,992/ ha), and B:C ratio (2.56). These results underscore the critical role of sowing date and spacing in optimizing the growth and yield of asalio. This research contributes valuable insights into the cultivation practices of asalio and can aid farmers and practitioners in making informed decisions to enhance productivity and economic returns.

Keywords: Garden cress, sowing time, spacing, vertisols

P/2.23

Performance of Ashwagandha under Different Sequence Cropping Systems

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An investigation was carried out to study different sequence cropping systems on yield and quality of Ashwagandha at Nagarjun Medicinal Plants Garden during 2017-18, 2018-19 and 2019-20. The experiment was conducted on clayey and slightly alkaline soil to identify suitable cropping system for higher root yield and quality of Ashwagandha. The experiment was laid out in Randomized Block Design with four replications and six treatments viz. soybean – ashwagandha, green gram – ashwagandha, black gram – ashwagandha, sunhemp – ashwagandha, dhaincha – ashwagandha and fallow – ashwagandha. Results revealed that significantly higher plant height of ashwagandha was recorded in dhaincha – ashwagandha cropping sequence (48.78 cm) and it was on par with preceding fallow, sunhemp, black gram and green gram. Number of branches per plant (6.38) of ashwagandha was significantly higher in green gram – ashwagandha sequence. Significantly higher root length of ashwagandha (20.58 cm) was recorded when it was preceded by sunhemp followed by treatments, where preceding crops were green gram, black gram, dhaincha and fallow. Mean root diameter of ashwagandha (9.00 mm) was significantly higher in green gram – ashwagandha

sequence and it was on par with preceding crops *viz.* black gram, sunhemp, dhaincha and fallow. Fresh root yield (1438.66 kg/ ha) and dry root yield (636.64 kg/ ha) of ashwagandha was recorded significantly higher in green gram – ashwagandha sequence which was on par with preceding crops soybean, dhaincha and fallow. Minimum fresh root yield (1026.44 kg/ ha) and dry root yield (473.18 kg/ha) was observed in black gram – ashwagandha sequence. Highest Withaferin-A (0.6875 mg/g) and Withanolide-A (0.5669 mg/g) content were recorded in ashwagandha preceded with green gram; whereas,12-deoxy withastramanolide showed non-significant results among the treatments.

Keywords: Indian ginseng, root yield, withaferin-A, Withanolide-A

P/2.24

Spices as Profitable Intercrops in Arecanut and Coconut Plantations of Andaman and Nicobar Islands

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The major area in Andaman and Nicobar Islands is occupied by monocropped arecanut and coconut plantations accounting for 60% of the total cultivated land. Due to emerging threats of pests and diseases such as slug caterpillar, rhinoceros beetle, *koleroga*, leaf spot in these crops, farmers are more prone to financial uncertainty. Considering suitable climatic conditions of the islands and boom in the herbal drug market in India, intercropping of spices in plantation crops is an alternative to safeguard the income of the island farmers. Andaman and Nicobar Islands have the potential to become *Isle of spices* if intercropping spices such as black pepper, nutmeg, clove and cinnamon in arecanut and coconut plantations are considered. Apart from using the spices as intercrops, they can also be used to cover vacant hilly lands, which are unused or partially used for any agricultural purpose. Cinnamon and clove grow well in hilly areas. They can also be used as border crops to help in the maximum utilisation of available land. However, there is a need to create awareness among the farmers about importance of intercropping, good agricultural practices and value addition of spices. Further, providing quality planting materials, improved technology demonstration through state-run farms and setting up value addition and marketing facilities in a mission mode plays a vital role in the shift from monocropping to multi-storied crop diversification. Apart from this, spices cultivation generates employment opportunities by way of spices processing, oils and oleoresins units, exports and marketing of spices. To realise the potential, coordinated efforts from all the stakeholders such as the Directorate of Agriculture, ICAR-CIARI, CIPMC, Spices Board, FPOs and other line departments are required to ensure sustainable yield and economic prosperity of the farmers and ecological sustainability of the island.

Keywords: employment generation, multi-storied cropping, value addition

P/2.25

Scope of Cultivation of Lemongrass in South Andaman District of Andaman and Nicobar Islands

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Lemongrass is an aromatic grass (Family: Poaceae), which grows in many parts of tropical and sub-tropical climates. However, ideal conditions for growing lemongrass are warm and humid climate with sufficient sunshine and evenly distributed rainfall of 2500-3300 mm per annum. A temperature ranging from 20-30 °C and good sunshine throughout the year is conducive for high crop yield. Lemongrass can grow well in medium fertile soils with moderate irrigation. Well drained sandy loam is most suitable for the growth of the plant. It can be grown on a variety of soils ranging from loam to poor laterite. In India, it is cultivated along Western Ghats (Maharashtra, Kerala), Karnataka and Tamil Nadu states besides foot-hills of Arunachal Pradesh and Sikkim. At present, in some parts of South Andaman district of Andaman and Nicobar Islands, people have started growing lemongrass in their kitchen gardens. Nearly 130 household in Ferrargunj Block, 1,250 household in Port Blair Block and 121 household in Little Andaman Block were found growing lemongrass in their kitchen garden. Locally, people are consuming the leaf as herbal tea on regular basis for their health benefits. People procure planting materials from ICAR-KVK, instructional farm, Sippighat South Andaman, ICAR-CIARI, Port Blair and Agriculture Department farm, which shows the importance of lemongrass cultivation in these parts of the islands. It has been observed that visiting tourists from mainland prefer tea prepared from this aromatic herb because of its aroma and taste. As a result, cultivation of lemongrass in South Andaman district is gaining momentum for their health benefits and it has tremendous market potential in hotel industry and resorts. Field surveys at different locations showed that there is no report on commercial cultivation of lemongrass so far. However, extension activities are required to farmers for its commercial cultivation. Lemongrass, if grown commercially, will provide an opportunity to Island farmers to boost their income and improve their livelihood.

Keywords: aromatic grass, extension, kitchen garden, surveys

P/2.26

Comparative Performance of the Medicinal Plants Suitable for the Rainfed Alfisol Tracts of Sivagangai District of Tamil Nadu

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A field experiment was carried out during the period from 2017-2020 at Dryland Agricultural Research Station, Chettinad, Sivagangai district of Tamil Nadu to study the comparative performance of medicinal plants under agroforestry systems in the rainfed alfisol conditions. In the present investigation, forty-five medicinal plant species were taken initially for the experimentation. Among these, five medicinal plant species were shortlisted based on preliminary studies. The observations like plant height, number of

branches, number of leaves per branch and herbage yield were recorded for three consecutive years in six seasons. Among these, *Vitex negundo* was found to be superior in all the growth characters, when compared with other species of medicinal plants like *Clerodendrum phlomides*, *Plectoranthus coloeides*, *Adathoda zeylanica* and *Ocimum sanctum*.

Keywords: growth parameters, *notchi*, *omavalli*, suitability

P/2.27

Effect of Bio-formulations, Organic and Inorganic Nutrient on Growth, Yield and Quality in Safed Musli (*Chlorophytum borivilianum* Sant. et Fernand.)

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An experiment was carried out at the Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2018-19 and 2019-20. The experimental results revealed that, growth parameters like maximum number of leaves (17.57), total dry matter production (8.21 g/ plant), leaf area (659.46 cm^2), LAI (1.47), root to shoot ratio (1.40) and yield parameters like maximum number of roots per plant (13.11), root length (10.99 cm), root girth (7.60 mm), highest fresh and dry root yield (38.41 q/ ha and 6.81 q/ ha, respectively), fresh root recovery (79.70%), higher net returns (₹ 3,58,409 per ha), lowest cost of production (₹ 97,409 per q) and higher returns per rupee (1.54) was observed in the treatment O_1F_1 *i.e.* panchagavya (3%) + 100% recommended doses of NPK (50:40:40 kg/ ha). However, the interaction of bio-formulations, inorganic and organics did not differ significantly with respect to total saponin content. Among bio-formulations, application of humic acid recorded higher total saponin content (1.18%) when compared with control. With respect to organic and inorganic nutrients, F_1: 100% recommended dose of NPK (50:40:40 kg/ ha) recorded significantly higher total saponin content (1.28%); while, the lower total saponin content (0.97%) was recorded in F_4: control. Similarly, fresh to dry root recovery (%) did not vary significantly due to interaction effect of bio-formulations and inorganic and organics. It ranged from 16.89% in control (O_4F_4) to 17.74% in O_1F_1 *i.e.* panchagavya (3%) + 100% recommended dose of NPK (50:40:40 kg/ ha).

Keywords: organic, total saponin, panchagavya, fresh root, yield

P/2.28

Effect of Growth Stimulants and Nursery media on Sprouting and Rooting of Orthotropic Shoots of Black Pepper (*Piper nigrum* L.) in Pro-trays

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An experiment was conducted at the Department of Plantation, Spice, Medicinal and Aromatic Crops, College of Horticulture, Mudigere during 2022-23 to assess the influence of growth stimulants and nursery media on sprouting and growth of the orthotropic cuttings using protrays. The growth stimulant experiment

consisted of eleven treatments *i.e.* NAA, IBA and their combination at different concentrations and tender coconut water dipping. While nursery media experiment had eight treatments, which consisted of cocopeat, vermicompost and their combinations with *Trichoderma viride*, *Pseudomonas fluroscense*, *Vesicular Arbuscular Mycorrhiza* (VAM) and Arka Microbial Consortia (AMC). All the treatments were replicated thrice and laid out in Completely Randomized Design in a naturally ventilated polyhouse. Among growth stimulants, significant difference was found in cuttings treated with tender coconut water, which recorded lowest number of days to sprout (6.00), 50% sprouting (11.81 days), mean days to sprouting (16.57), highest length of sprouted cutting (12.55 cm) and number of leaves (2.13). The highest sprouting (96.29%) was recorded in the cuttings treated with NAA@100 ppm at 60 days after planting. The cuttings dipped in tap water recorded maximum leaf length (10.23 cm), leaf breadth (7.23 cm) and total leaf area (80.53 cm^2) at 90 days after planting. Among nursery media, significant difference was found and cuttings planted with cocopeat + vermicompost + *Pseudomonas fluroscense* recorded the lowest number of days to sprout (9.00), mean days to sprouting (19.87), maximum number of leaves (1.67), length of sprouted cutting (8.36), leaf length (9.33 cm), leaf breadth (7.97 cm) and total leaf area (84.90 cm^2). The media consisting of cocopeat + vermicompost + VAM recorded lowest days (18.37) for 50% sprouting and highest sprouting (68.51 %).

Keywords: *Piper nigrum*, orthotropic shoots, pro-trays, growth stimulants, bio agents.

P/2.29

Effect of Foliar Application of Organics on Growth and Yield of Coriander

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The present study was carried out to study the effect of foliar application of organics on growth and yield of coriander var. GDLC-1 during Rabi season in the year 2022-2023. The experiment was laid out in Randomized Block Design with three replications and nine treatments *viz. Panchagavya* @ 1.5 % (T_1), *Panchagavya* @ 3 % (T_2), novel organic liquid nutrients @ 1.5 % (T_3), novel organic liquid nutrients @ 3 % (T_4), vermiwash @ 1.5 % (T_5), vermiwash @ 3 % (T_6), cow urine @ 1.5 % (T_7), cow urine @ 3 % (T_8) and control (T_9). The foliar sprays were given at 20 and 45 days after sowing. Results revealed that foliar application of novel organic liquid nutrients @ 1.5 % (T_3) showed highest total chlorophyll content (1.64 mg/ g and 1.71 mg/ g), photosynthetic rate (12.24 µmol/ m^2/ s and 13.10 µmol/ m^2/ s), transpiration rate (3.48 m mole/ m^2/ s and 3.69 m mole/ m^2 / s), stomatal conductance (0.21 mol/ m^2 / s and 0.22 mol/ m^2 / s) at 30 and 50 days after sowing, respectively. In case of growth parameters, maximum plant height (39.14 cm and 27.87 cm), number of branches per plant (11.73 and 20.20), petiole length (18.57 cm and 10.07 cm), leaf length (3.93 cm and 3.77 cm) and leaf width (4.05 cm and 3.84 cm) were observed under the same treatment. Among different treatments, foliar application of novel organic liquid nutrients @ 1.5 % (T_3) recorded significantly lowest days for first cutting (30.00) and maximum fresh weight of herbage per plant (18.47 g and 24.40 g) at 30 and 50 days after sowing, respectively. However, the data on herbage yield at first cutting (9.13 t/ ha), herbage yield at second cutting (11.70 t/ ha) and fresh weight of herbage (20.83 t/ ha) at both the cuttings were also recorded highest in the same treatment.

Key words: cilantro, herb, nutrients, photosynthesis

P/2.30

Integrated Nutrient Management in Turmeric (*Curcuma longa* L.) cv. GNT-2

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The field investigation was carried out with an objective to standardize the integrated nutrient management in turmeric cv. GNT-2 during Kharif season of the year 2021-22. The experiment was conducted in Randomized Block Design, which included ten treatments and three replications. Ten treatments included- T_1: recommended dose of fertilizers - RDF (farmyard manure, FYM @ 20 t/ ha + 60:60:60 NPK kg/ ha), T_2: FYM 15 t/ ha + 75 % RDF, T_3: FYM 20 t/ ha + 50 % RDF, T_4: vermicompost 10 t/ ha + 75 % RDF, T_5: vermicompost 15 t/ ha + 50 % RDF, T_6: bio-compost 10 t/ ha + 75 % RDF, T_7: bio-compost 15 t/ ha + 50 % RDF, T_8: FYM 15 t/ ha + 50 % RDF + novel organic liquid nutrients 5 %, T_9: vermicompost 10 t/ ha + 50 % RDF + novel organic liquid nutrients 5 % and T_{10}: bio-compost 10 t/ ha + 50 % RDF + novel organic liquid nutrients 5 %. Organics (FYM, vermicompost and bio-compost) were applied at the time of planting, whereas inorganic (N-Urea, P-SSP and K-MOP) *i.e.* nitrogen and potash were applied in three equal splits (basal, 30 and 60 DAP) while, full dose of phosphorus was applied at the time of planting. The foliar application of novel organic liquid nutrients was done at 60, 90 and 120 days after planting. The result revealed that application of FYM 15 t/ ha + 50 % RDF + novel organic liquid nutrients 5 % (T_8) recorded the highest plant height (62.78 cm, 130.13 cm and 135.47 cm), number of tillers per plant (1.60, 3.43 and 5.22), number of leaves per plant (7.08, 9.77 and 12.27), length of leaf (32.65 cm, 58.50 cm and 81.21 cm) and breadth of leaf (12.13 cm, 14.44 cm and 18.09 cm) at 75, 135 and 195 DAP, respectively. In case of yield and yield attributes, the maximum number of mother rhizomes per plant (3.54), number of fingers rhizomes per plant (18.57), weight of mother rhizomes (53.26 g/ plant) and fresh rhizomes yield (317.80 g/ plant and 34.26 t/ ha) were observed under the same treatment. Quality aspects *viz.* curcumin content (4.93 %) and essential oil (3.67 %) were found significantly higher with vermicompost 10 t/ ha + 50 % RDF + novel organic liquid nutrients 5 % (T_9). From the economics point of view, the highest benefit cost ratio (3.77) and the maximum net realization (Rs. 6,76,970 per ha) was obtained under FYM 15 t/ ha + 50 % RDF + Novel organic liquid nutrients 5 % (T_8). Moreover, application of FYM 20 t/ ha+ 50 % RDF (T_3) improved the soil nutrient status.

Key words: Turmeric, growth, nutrient, quality, yield

Theme 3: Crop Protection Technologies for Getting Residue-free produce of spices and MAPs

Invited Talks

Dr. R. Dinesh

Dr. R. Dinesh, Director, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala has made significant contributions in soil fertility/ soil biochemistry/ soil microbiology with major focus on plant-microbe interactions and their influence on nutrient cycling in soils under perennial horticulture. He started his career as Scientist at ICAR-CIARI, Port Blair in 1994, where he worked on arable soils and soils under tropical forests and mangrove ecosystems. At ICAR- IISR, Kozhikode he worked on nutrient management in major spices and agriculturally important microorganisms. He is one of the inventors of the smart and novel delivery system for plant beneficial microbes through encapsulation (biocapsules), which is the first of its kind in the world biofertilizer industry. He also co-developed designer micronutrient and PGPR formulations specific to spice crops, which have been licensed to many private agencies. He is also the co-inventor of a new liquid process for rapid and mass multiplication of *P. chlamydosporia*, novel protocol to prime seed rhizomes and tubers using microbes and the unique lime based microbial formulation. His products and processes have six patents and have been non-exclusively licensed to several national and international companies. He was also involved in the development of organic and integrated nutrient management plans and GAPS for ginger, turmeric, black pepper and cardamom and soil-based land use plans for Kerala state. Besides several publications in high impact journals, he was recognised with several awards including the Fellow of NAAS, New Delhi, Recognition award of NAAS, New Delhi, Young Scientist Award of NAAS, New Delhi and Young Scientist award of the Indian Society of Soil Science, New Delhi.

IT/3.01

Beneficial Microbes in Spices Production

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Excessive use of chemical fertilizers and plant protection chemicals affects soil health and non-target organisms, result in pesticide residues in the produce and cause human and environmental hazards. Spices are high-value products and are extensively used all over the world to add flavour and taste to human food besides being used in indigenous medicine. In India, spices are cultivated in an area of 4.43 mha with a production of 11.14 mt during 2022-23. The export of spices/ spice products from the country has been 1.40 mt valued at Rs. 31,761 crores (3.95 billion US$) during 2022-23. The spices economy of the country has proved its vital role in the agricultural sector owing to its high value of output role contributing 43% of the total horticultural exports from India, indicating its importance in agricultural export basket, even during the COVID pandemic. At ICAR-IISR, several technologies have been developed by utilizing beneficial microbes for combating various pests and diseases apart from providing nutrition to the crops. A talc and biocapsule based formulation (IISR Biomix) consisting of a consortium of PGPR [*Micrococcus luteus* (BRB 3)] + [*Enterobacter aerogenes* (BRB 13)] + [*Micrococcus* sp. (BRB 23)] has been developed for application in the nursery and main field for enhanced growth and yield. Soil solarization and fortifying the nursery mixture with *Trichoderma* sp. and *Pochonia chlamydosporia* in black pepper and cardamom gives protection from *Phytophthora capsici*, *P. meadii* and *Pythium* sp. and the nematodes *Radopholus similis* and *Meloidogyne incognita*. PGPR consortia have also been developed to promote rooting and growth of plants and controlling diseases in the nursery. Liquid formulation of *Trichoderma* sp. has been developed containing minimum population of 10^8 fungal spores per ml that can be stored up to 1 year without significant reduction in viable cells. In ginger, *Bacillus amyloliquefaciens* (PGPR) as seed treatment and drenching are helpful in managing rhizome rot disease incidence in the field. IDM protocols involving $CaCl_2$ and *Bacillus lichiniformis* based formulation for the control of bacterial wilt of ginger was standardized and demonstrated across India. Technologies like, *Pochonia chlamydosporia*, a biocontrol agent against nematodes, use of an entomopathogenic fungus, *Lecanicillium psalliotae*, for controlling the cardamom thrips *etc*. offers immense scope for reducing the pesticide use in spice based cropping systems. ICAR-IISR has made a significant breakthrough in encapsulation and delivery of PGPR for growth promotion and disease control in ginger. The encapsulation process is simple and can be used to deliver all kinds agriculturally important microorganisms such as N fixers, nutrient solubilizers and mobilizers, PGPR, *Trichoderma* sp. *etc*. Spinosad (derived from the Actinomycetes) can substitute synthetic insecticides for thrips control in cardamom, when sprayed three times (March, May and August). Entomopathogens such as *Metarhizium anisopliae* and *Beauvaeria bassiana* are effective against root grubs in cardamom and white grubs in ginger. The entomophagous nematode *Heterorhabitidis indica* was found promising in controlling root grub infestation in cardamom and *Oschieus gingeri* and *Steinernema* sp. against shoot borer infestation in ginger and turmeric.

Dr. Vandana Tripathy

Dr. Vandana Tripathy did her M. Sc. (Agrochemicals and Pest Management) from University of Delhi in 1997 after which she completed her Ph.D. (Agricultural Chemicals) during 2003 from ICAR- Indian Agricultural Research Institute, New Delhi. She is presently working as Network Coordinator and Principal Scientist, All India Network Project on Pesticide Residues (AINP-PR), ICAR-Indian Agricultural Research Institute, New Delhi and Scheme In-charge, Monitoring of Pesticide Residues at National Level. Before joining the present responsibilities, she worked as Senior Scientist at ICAR-Directorate of Medicinal and Aromatic Plants Research (DMAPR), Anand, Gujarat. Dr. Tripathy has over 20 years of experience in the field of pesticide residues, food safety and development of new analytical methods of detection of pesticide residues in food commodities. She has served as Chair/Co-Chair/Member of various electronic Working Groups (eWG) of Codex Committee on Pesticide Residues (CCPR). She was a Member of Indian delegation at 52nd, 53rd and 54th Session of FAO/WHO/CCPR. She was nominated as Expert by International Atomic Energy Agency (IAEA) for Regional Training Course on Monitoring Pesticide Residues in Food at Jordan. She is a Member of Food Safety and Standards Authority of India (FSSAI) apart from being on the Scientific Panel on Pesticide Residues and Co-opted member for Registration Committee constituted under the Insecticide Act, 1968. She is serving as a technical expert in various scientific committees of the Department of Agriculture & Farmers Welfare (DA&FW), Central Insecticide Board & Registration Committee (CIB&RC), Bureau of Indian Standards (BIS) and Ministry of Commerce. She is a certified NABL assessor for auditing the laboratories as per ISO/IEC 17025:2017 in the field of pesticide residue analysis. She has been awarded with Meritorious Invention Award of Rs 5.0 lakhs (2010) by National Research Development Corporation (NRDC), DSIR, Ministry of Science and Technology, Govt of India and the IARI Merit Gold Medal for the year 2003 for Outstanding Research in the Agricultural Chemicals, ICAR- IARI, New Delhi. She has published two patents to her credit apart from more than 50 research papers in peer reviewed national and international journals of repute.

IT/3.02

Pesticide Residues in Spices: National and Global Perspective

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India, also known as the world's spice bowl, is one of the largest producer, consumer, and exporter of spices in the world. With the growth in demand for spices globally, Indian farmers find the cultivation of spices a lucrative option. Spice crops such as cumin, black pepper, cardamom, ginger and turmeric are attacked by various insect-pests such as thrips, mites, top shoot borer, root grub and diseases such as anthracnose which can cause severe yield losses, sometimes going up to 100%. In order to tackle this persistent problem, farmers resort to the use of pesticides in their fields. The indiscriminate use of chemical pesticides however, poses serious challenge to the consumer safety. The primary challenge is that of food safety, wherein the pesticide residues above permissible levels act as a major bottleneck in spice trade. Limited number of maximum residue limits (MRLs) of pesticides on spices is another challenge due to the limited availability of field residue GAP data as well as because of spice being classified as minor crops. Absence of domestic MRLs and detection of off-label pesticides in spice exports pose serious non-tariff trade barriers, which hampers smooth export of spices from India. These challenges may be addressed to some extent by adopting Codex principles of crop grouping for the extrapolation of MRLs for pesticides to commodity groups. At the international front, through the ICAR-All India Network Project on Pesticide Residues (AINP-PR) and Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare sponsored central sector project on "Monitoring of Pesticide Residue at National Level (MPRNL), India has been regularly submitting the pesticide residue monitoring data on spices to FAO/WHO/JMPR for risk assessment and fixation of Codex MRL. Based on the residue data, 20 Codex MRLs have been fixed for pesticides on spices, which have eased trade barriers and facilitated smooth export of spices from India thereby increasing the farmers' income and earning foreign exchange. Further, expanding label claim of pesticides on spices, encouraging industry to generate data as per regulatory requirements and expediting the process of fixation of MRLs on spices as well as harmonizing them with international standards would facilitate fair trade practices and help India promote its role as one of the major producers and exporters of the spices in the world.

Keywords: export commodity, label claims, residues, trade

Theme 3: Crop Protection Technologies for Getting Residue-free produce of spices and MAPs

Oral Presentations

O/3.01

Management of Fungal Foliar Diseases of Chilli by Eco-friendly Fungicide Molecule

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Chilli (*Capsicum annum* L.) is an important vegetable cum spice crop grown in almost all tropical and subtropical countries of the world. Chilli is known for its outstanding taste, nutritive value and is popular because of its low sodium content, cholesterol free nature, richness in vitamin A, C and E, potassium and folic acid. India ranks second among world's chilli exporting countries and this growth has showed a steady decline in chilli trade due to an increased domestic consumption along with biotic and abiotic stresses. Among the biotic stresses, foliar diseases *viz*. powdery mildew, leaf spots and anthracnose or fruit rot are acting as major yield limiting factors with considerable yield loss. Hence management of fungal foliar diseases using eco-friendly fungicide molecules has been a high priority area of research to produce residue free produce. In this regard, an experiment was conducted with copper oxychloride (14%) + copper hydroxide (14%) against foliar fungal diseases. Among the different concentrations of chemical tested, copper oxychloride (14%) + copper hydroxide (14%) at 5000 g a.i./ ha showed minimum powdery mildew, leaf spot and fruit rot severity (22.67, 6.67 and 6.67 %, respectively) with maximum fruit yield (21.53 q/ha). This treatment remained on par with copper oxychloride (14%) + copper hydroxide (14%) sprayed at 4000 g a.i. /ha in which powdery mildew, leaf spot and fruit rot severity of 28.67, 7.33 and 5.00%, respectively was recorded with fruit yield of 21.20 q/ha. Check *i.e.* difencoazole 25% SC (0.1%) recorded powdery mildew, leaf spot and fruit rot severity of 39.33, 10.00 and 9.17%, respectively with the fruit yield of 14.73 q/ha; whereas the unsprayed plots recorded disease severity of 54.00, 14.00 and 12.50% with the fruit yield of 11.17 q/ha. The residue analysis of chilli samples and soil revealed that samples were free from residues and thus the treatment could be used for the eco-friendly management of fungal foliar diseases of chilli.

Keywords: Chilli, fruit rot, leaf spot, powdery mildew, yield

O/3.02

Study on Insect-pests and Disease Dynamics in Onion under Tripura Conditions

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Onion is an important spice crop in every Indian's kitchen due to its versatile use. The spice is also one of the profitable crops for the farmers. Onion cultivation in Tripura is a new venture of income as the maximum requirement of the state is being met from the import from other states. Tripura produces 1,235 MT of onions from an area of 193 ha giving a productivity of 6.45 MT/ha. The climate and soil of the state is suitable for onion cultivation and there is a huge scope of its cultivation during late kharif and rabi seasons. However, for ensuring the successful onion cultivation, one needs to understand the insects-pest and disease dynamics in the region. The study was conducted during 2020 – 21 to understand the occurrences for various insect-pests and diseases in onion cultivation in Tripura. The incidence of diseases varied and purple blotch

(18.5%), Stemphylium blight (25.5%) and basal rot (23.6%) were reported in onion var. Bhima Shakti under Tripura condition. Regarding the pest incidence, maximum damage was caused by thrips (41.3%) followed by *Helicoverpa armigera* (26.2%) and *Chrysodeixis acuta* (16.5%) with peak damage during the month of January-February. Different planting dates revealed that thrips started to emerge from last week of December and population was higher during January to first week of March and then declined. This study would help in understanding the potential threats for promoting onion as a commercial crop in the state of Tripura.

Keywords: basal rot, purple blotch, Stemphylium blight, thrips

O/3.03

Performance of Black Pepper Genotypes with reference to Flowering Behaviour, Bearing Tendency, Yield and Disease Reaction under Arecanut based Cropping System

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Black pepper, renowned as the 'King of spices,' is a crucial spice with an extensive genetic diversity. It is cultivated commercially in the tropical regions of the nation due to its prominence and trade significance in the global market. The area under the crop has expanded quickly, often alongside crops like arecanut, coconut, and coffee. However, productivity is decreasing gradually due to variations in crop performance, nutrient management and disease outbreaks. Evaluation of local cultivars/ varieties would help in identifying the superior varieties. In light of this, an experiment was carried out to study the performance of black pepper cultivars with particular reference to flowering behaviour, bearing tendency, yield and disease reaction under arecanut based cropping system. Experiment comprised of Block–I [Sigandini and Panniyur-1(Check)] and Block-II [Neelamundi and Panniyur-1(Check)]. Growth, yield and quality attributes were assessed and incidence of major diseases was noted. In Block I, highest growth and yield attributes like plant height, leaf length, number of runners per vine and number of laterals per m^2, higher spike length, spike weight and number of berries per spike were recorded in cv. Sigandini, when compared with the check. Considering the pest and disease incidence, the least disease incidence of foot rot and slow wilt was recorded in Sigandini (8.34 and 8.75 % respectively) compared to Panniyur-1. Whereas, In Block II, Neelamundi recorded the lower plant growth and yield attributes compared to the check variety. Least disease incidence of foot rot and slow wilt was observed in cv. Neelamundi (13.32 and 16.25 %, respectively) compared to Panniyur-1 (20.00 and 21.25 %, respectively). Thus, the variety Sigandini exhibited superior performance when compared to national hybrid of black pepper Panniyur-1. Whereas, the cultivar Neelamundi recorded maximum bulk density which is one of the important quality attributes in the international trade of black pepper. The experiment revealed superiority of cultivars Sigandini and Neelamundi over Panniyur-1.

Keywords: cultivars, foot rot, mixed cropping, slow wilt

O/3.04

Biointensive Mitigation of Powdery Mildew, Anthracnose and Fruit Rot to Produce Residue Free Chilli

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Chilli (*Capsicum annuum* L.) is mainly cultivated for green fruits as table purpose and dry red chilli as spice. The spice "red pepper" is one of the most popular, highly remunerative crops of Indian subcontinent and is being grown both in tropical and subtropical regions of the world. Chilli crop is valued for its pungency (alkaloid, capsaicin) and red pigments (capsanthin, capsorubin and capxanthin), due to which it is traditionally consumed as vegetable, spice, condiment, sauce and pickle apart from its applications in pharmaceutical, cosmetic and beverage. India is a major producer, exporter and consumer of chillies in the world. Animate is the leading factor in restricting the economic yield of chilli majorly powdery mildew, anthracnose and fruit rot. Highly effective fungicides are available for the management of these diseases but most of those result in the residual toxicity to human beings. Hence, the present investigation was designed to manage the diseases with potential bioagents and probiotics aiming for residue-free chilli fruit production apart from studying the defence induction by enzymatic activities. Among all the treatments, soil application of farmyard manure (250 kg/ha) enriched with *Trichoderma asperellum* (Ta-1) (2.5 kg) followed by four prophylactic sprays with consortium of *Pseudomonas fluorescens* (BGREB 73), *Lactobacillus plantarum* (MYSVB1) and *Pichia* sp. (5 g/L) at 35 days after transplanting with 15 days interval recorded the maximum activity of polyphenol oxidase (1.23 change in the absorbance 495 nm/ min/ mg protein), peroxidise (0.92 change in the absorbance 420 nm/ min/ mg protein) and phenylalanine ammonia lyase (28.78 change in the absorbance 290 nm/ min/ mg protein) with less intensity of powdery mildew (12.00%), anthracnose (9.67%) and fruit rot (5.67%) coupled with maximum fruit yield (22.64 q/ha). The GC-MS analysis of the harvested chilli fruits from each treatment revealed fruits were free from pesticide residues. This extensive study is an alternative and potential practice in mitigating the chili diseases with residue-free production.

Keywords: *Lactobacillus plantarum*, *Pichia* sp., *Pseudomonas fluorescens*, Residue free, *Trichoderma asperellum*

O/3.05

Biological Control of Slow Decline and Production of Ecosafe Black Pepper

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Slow decline is a serious threat to black pepper and it is a complex disease incited by nematodes and fungi, disease typically starts with subtle symptoms that can be easily overlooked. These include wilting of leaves, yellowing of foliage, and a gradual reduction in the plant's overall vigour. In order to evaluate novel bio control agents such as actinomycetes and fungicide (Kresoxim methyl) a trial was commenced in 2020 and involved the following treatments, T_1: Foliar spray with Bordeaux mixture (1%) and soil application

of a combination of Actinobacteria (Act 1+5+9) at a rate of 50 g per vine. T_2: Foliar spray with Bordeaux mixture (1%) and soil application of *Trichoderma harzianum* (MTCC 5179) and *Pochonia chlamydosporia* (MTCC 5412) at a rate of 50 g per vine. T_3: Foliar application of Ergon 44.3% (W/W) [Kresoxim methyl 500 G/L] and soil application of Ergon (7ml/lit) + Carbosulfan (1ml/L) at a rate of 2-3 L per vine, T_4: Foliar application of metalaxyl-mancozeb at 1.25g/L and soil application of metalaxyl-mancozeb at 1.25g/L + carbosulfan (1 ml/L), T_5: Recommended state package of practices. The trial was conducted at farmers holding in RBD design with four replication and the results from three years of combined data analysis indicated that treatments T_1 and T_2 exhibited superior performance compared to the other treatments by significantly reduced disease incidence. Additionally, the analysis of residue data revealed the absence of any detectable fungicides (MRL) in these treatments, ensuring the safe production of black pepper. In addition to a decrease in disease incidence, there was also a noticeable increase in yield.

Keywords: Black pepper, slow decline, residue, actinomycetes

Theme 3: Crop Protection Technologies for Getting Residue-free produce of spices and MAPs

Poster Presentations

P/3.01

Screening of Turmeric Genotypes against Shoot Borer (*Conogethes punctiferalis*)

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A field experiment was carried out at the Instructional Farm of Department of Vegetable Science of authors' institute during 2020-21 to find out promising genotypes against shoot borer *i.e. Conogethes punctiferalis*. A set of 24 genotypes were used for experiment *viz.* PWTM-1, PWTM-3, PWTM-4, PWTM-5, PWTM-6, PWTM-8, PWTM-9, PWTM-10, PWTM-11, PWTM-14, PWTM-19, AKTL-3, AKTL-8, AKTL-10, AKTL-11, AKTL-12, AKTL-13, AKTL-16, AKTL-18, AKTL-19, PDKV Waigaon, PTS-10, Salem and Pragati. Out of 24 genotypes evaluated, the minimum percent of infestation was noticed in three genotypes, *i.e.* PWTM-9 (0.9%), AKTL-12 (2.3%), AKTL-11 (3.2%). Overall mean shoot infestation varied from 0.9% in PWTM-14 to 15.8% in PWTM-9. Among the 24 genotypes, 21 genotypes registered 0.10- 12.50% shoot infestation and were graded as moderately resistant, while remaining three genotypes showed 12.60-17.10% shoot infestation with moderately resistant grade. None of the genotype were found highly resistant, susceptible and highly susceptible. Statistical analysis of correlation co-efficient between mean infestation and weather parameter showed non- significant correlation. Correlation between mean infestation and plant height, number of tillers showed non- significant correlation and correlation of mean infestation with leaf lamina was significantly correlated. The present findings indicate that three genotypes *viz*. PWTM-9, AKTL-12 and AKTL-11 showed minimum percent of infestation and can be further explored for development of new varieties.

Keywords: *Conogethes punctiferalis*, correlation, screening, shoot borer, turmeric

P/3.02

Weed management in *Rabi* Onion (*Allium cepa* L.) under the North West Plateau Zone of Odisha: a Comparative Evaluation of Different Herbicides

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Onion (*Allium cepa* L.) is one of the oldest and commercially grown vegetable spices cultivated around the globe. India is the second largest onion producer, producing around 24 million metric tonnes per annum from an average area of 1.4 million hectares. It is true that the nation has a good position for this particular crop, but onion production and productivity fluctuated frequently, which results in an increase in domestic market prices that impact consumer budgets. On the other hand, when the market price falls below the cost of cultivation, the farmer's marginal profit is drastically reduced. Likewise, it is a key factor in the determination of profitability in rural microeconomic situations for growers. The productivity and profitability of this crop entirely depend on good cultivation practices. The most destructive component in onion production is weeds. They propagate either through undecomposed seeds or rhizomes and compete for space, light, water and nutrients available in the soil. The present-on-farm testing (OFT) was conducted under the irrigated

upland situation to authenticate the effectiveness of herbicides, which will address the above-said issues. The effectiveness of two weed management practices comprising the pre and post-emergency herbicides was compared with manual hand weeding in onion crop cultivation replicating seven times in farmer's field with an estimated area of one hector. Results obtained from this investigation expressed a significant reduction in weed population with the application of Oxyfluorfen 23.5 EC @ 1.5ml/ L and one-hand weeding at 55 days after transplanting (DAT) (07 weeds m^2) as compared with the application of Pendimethalin 750 g/ ha followed by the application of Quizalophop ethyl 50g/ ha at 20 DAT (10 weeds m^2) and manual hand weeding (28 weeds/ m^2). The onion bulb yield (q/ ha) and the net income (Rs./ ha) followed the same trend expressing the higher bulb yield of 214 q/ ha and net income of Rs. 1,58,300/- per ha due to the application of Oxyfluorfen 23.5 EC @ 1.5ml/L and one-hand weeding at 55 days after transplanting (DAT) followed by the application of Quizalophop ethyl 50g/ ha at 20 DAT and manual hand weeding with 205 q/ ha of bulb yield and Rs.1,48,500/- of net income per hectare. Manual weeding in onion crops is comparatively more costly, time taking and results in inferior bulb production. Hence, the application of Oxyfluorfen 23.5 EC @ 1.5ml/ L and one-hand weeding at 55 days after transplanting can be profitable for the onion growers.

Keywords: Economics, Bulb yield, Oxyfluorfen, Pendimethalin, Quizalophop ethyl

P/3.03

Evaluation of *Trichoderma viride* Grown on Different Solid Substrates

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The global biopesticides market is booming with a major share of various commercial formulations of *Trichoderma* spp. However, the cost of these raw materials or commercial production of bio-control agents is one of the major limitations behind the restricted use. To overcome the cost limitation, many researchers have successfully used substrates of various agricultural and domestic wastes to develop an effective formulation and mass multiplication of *Trichoderma* spp. Seven different substrates *viz*. sugarcane bagasse, shelled maize cob powder, talc powder, spent mushroom compost waste, neem cake, vermicompost and farmyard manure were tested for maximum biomass production of *Trichoderma viride.* Among these, maize cob powder was found most suitable with highest (25.054 g fresh and 0.054 g dry weight of mycelium) biomass production of *Trichoderma viride*, followed by sugarcane bagasse with 25.040 g fresh and 0.040 g dry weight. Rest of the substrates showed different fresh and dry biomass production potential *i.e.* neem cake (25.027 and 0.027 g), farmyard manure (25.024 and 0.024), vermicompost (25.013 and 0.013) and spent mushroom compost waste (25.010 and 0.010 g). No biomass of *T. viride* was obtained in talc powder. The results on the colony forming units (cfu/g) was recorded with maximum 112.6×10^6 cfu/g in shelled maize cob powder followed by 108.6×10^6 cfu/g in sugarcane bagasse. The colony forming units in other substrates were of the order: vermicompost (108.3×10^6 cfu/g), talc powder (102.3×10^6 cfu/g), neem cake (102×10^6 cfu/g), farmyard manure (101.6×10^6 cfu/g) and spent mushroom compost waste (100.6×10^6 cfu/g).

Keywords: biomass, colony forming units, maize cob powder, substrate

P/3.04

Determination of Dissipation Pattern of Bifenthrin and Quinalphos Residues in Chilli

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A supervised field trial was conducted to study the dissipation of bifenthrin and quinalphos, at Dhevarayapuram village, Coimbatore District, Tamil Nadu on the chillies TNAU hybrid CO-1. Quinalphos 25 EC @ 250 and 500 g a.i./ ha and Bifenthrin 10 EC @ 50 and 100 g a.i./ ha were sprayed twice at 15 days interval from fruit initiation stage and fruit sample was collected at 0 (one hour after spraying), 1, 3, 5, 7, 10, 15 and 21 days after second spray along with control samples. Method with accepted specificity (% RSD < 2), good linearity (R = 0.996 and 0.998), recovery (91.36 to 92.68 % and 91.82 to 99.54 % with < 5 % RSD) and satisfactory repeatability was developed in Gas chromatograph (GC) with Electron Capture Detector (ECD). The LOD and LOQ values were 0.015 and 0.05 mg/kg for quinalphos and 0.033 and 0.1 mg/kg for bifenthrin, respectively. The initial mean deposit of quinalphos 25 EC @ 250 and 500 g a.i./ ha were 1.929 and 2.773 µg/g, which dissipated to below detectable level on tenth and fifteenth day after spraying, respectively; whereas in bifenthrin 10 EC @ 50 and 100 g a.i./ ha, mean initial deposit was 0.946 µg/g and 1.180 µg/g, which dissipated to below detectable level on fifth day after spraying. The decline behaviour of the persistent residues was computed following seven transformations and the best fit was selected among them. Based on the coefficient of determination, the best fit observed was first order reaction for both insecticides. The half-life of quinalphos @ 250 and 500 g a.i./ha were 2.29 and 3.74 days and bifenthrin 10 EC @ 50 and 100 g a.i./ha were 0.89 and 1.02 days, respectively.

Keywords: Bifenthrin, dissipation, pesticide residue, Quinalphos

P/3.05

Exogenous Melatonin Escalates Physiological Activities and Pharmacological Potential by Restraining the Accumulation of Heavy Metal in *Trigonella foenum-graecum L.* Exposed to Nickel Stress

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Fenugreek (*Trigonella foenum-graecum* L.), an important medicinal spice crop of India, is severely disturbed by toxic levels of nickel (Ni) in soil. It is reported that Ni applied at 80 mg/ kg soil causes a heavy toll on the performance of fenugreek crop. Melatonin is an emerging plant growth regulator that plays a key role in amelioration of heavy metal stress. Foliar feeding of various concentrations *viz*. 0, 25, 50, 75 and 100 µM of melatonin in Ni-stressed fenugreek plants positively modulated root-shoot lengths, fresh and dry weights and restored photosynthetic efficiency through incrementing F_v/F_m, YII, qP and lowering NPQ values. This study highlights that melatonin also triggered the activities of antioxidant enzymes like SOD, POX and CAT against Ni-induced oxidative stress and lowered MDA and H_2O_2 generation. Moreover, melatonin follow-up treatment under stress conditions efficiently lowered Ni accumulation in roots and shoots and enhanced its translocation to reduce Ni generated toxic impacts on root architecture. Additionally, 75 µM of melatonin

conspicuously upscaled the concentrations of total phenols, total tannins, total flavonoids and total alkaloids by 13.6, 11.2, 25.5 and 19.2%, respectively in fenugreek's leaves over Ni-stressed plants. Furthermore, seed trigonelline content was also augmented than Ni-disturbed plants, escalating the overall pharmacological potential of the crop. Thus, the present study deciphered the envisaged roles of melatonin on fenugreek, for circumventing Ni-induced phytotoxicity, chiefly by restricting Ni accumulation in plant tissues as well as boosting photosynthesis, secondary metabolism and redox balance.

Keywords: Antioxidant enzyme, fenugreek, heavy metal stress, toxicity

P/3.06

Screening of Chilli (*Capsicum annum*) Genotypes Against Root-knot Nematode, *Meloidogyne incognita* (Kofoid and White) for Resistance Tagging

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Chilli (*Capsicum annum*) is an important condiment crop grown throughout the world and it is adversely affected by the root parasite known as root-knot nematode (*Meloidogyne incognita*). Drastic effects on yield and quality of the crop are evidenced by this species. Resistant genotypes are thus needed to mitigate the adverse effects of this nematode and to get economic yields. Therefore, this investigation was carried out to find the resistant genotypes against root-knot nematode. Chilli genotypes were collected from in and around Cuddalore and Ramanathapuram district and maintained at authors' institute. The nematode screening trial was carried out in the central farm area with 5 samba type genotypes and 25 mundu type genotypes. The chilli genotypes seeds were sown in *M. incognita* infested sick plots with >1 nematode/ g of soil during January 2023. The trial was terminated 60 days after sowing and the observations were taken on number of galls per root system, number of egg masses per root system and root-knot index (RKI). The resistance scoring was done by using root-knot index scale by Talor and Sasser's. The results revealed that the Mundu type- PKM CA 20, PKM CA 33, PKM CA 38, PKM CA 08, Samba type - PKM CA (C) 1, PKM CA (B) 2, PKM CA (P) 2, PKM CA (GL) 2 showed highly resistant reaction against *M. incognita* with RKI of 0. Twenty genotypes were observed as resistant, while two were recorded as susceptible genotypes. These highly resistant genotypes could be recommended in the nematode infested fields and could also be used as rootstocks in grafting under nematode infested soil conditions.

Keywords: *Capsicum annum*, resistance screening, root-knot index, sick plot

P/3.07

Unravelling the Potential of Fungal Bioagents for the *In vitro* Management of Leaf Blight Disease of *Stevia rebaudiana* Caused by *Alternaria alternata*

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Stevia rebaudiana, a herbaceous perennial prized for its natural sweetness, has gained global acclaim and found in various parts of India. Investigation on leaf spot disease (*Alternaria alternata* (FR.) Keissler) of

Stevia under South Karnataka condition was carried out to find out suitable management strategies. Symptoms initially appeared as small circular spots, light brown in colour. Later, the spots became irregular and dark brown to grey, while others remained circular with concentric rings or zones. On severely affected leaves several spots coalesced to form large necrotic areas. On older leaves concentric spots were more common at the tips. Leaf spots varied from 2-18 mm in diameter. Conidial dimensions varied from 10–40 × 6-12 mm, mid to dark brown or olive-brown in colour, short beaked, borne in long chains, oval and bean shaped with 3–5 transverse septa. Due to hazardous effect of chemical fungicides, search for safer alternative to control the pathogen is better choice. This led to trials on the use of bioagents to control the pathogen. The six known bioagents were evaluated by dual culture, pathogen at periphery and pathogen at the center technique to monitor antagonistic effect. The results revealed that out of all the six bioagents used, two bioagents *viz*. *Trichoderma viride* (Bangalore isolate) (74.77%, 69.04% and 79.45%) and *T. harzianum* (71.25%, 59.96% and 74.78%) showed maximum growth inhibition in dual culture, pathogen at periphery and pathogen at the center methods, respectively. Unraveled the strong antagonistic effect to inhibit the mycelia growth of the pathogen significantly.

Keywords: Antagonistic, inhibition, pathogen, *Trichoderma*

P/3.08

Botanical Approach for Enhancing Fungistatism in the Biological Management of *Alternaria solani* Causing Early Blight in Potato

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Potato (*Solanum tuberosum*), also known as poor man's friend is the world's third most important food crop after wheat and rice. It is cultivated in an area of 4.62 ('000 ha) with the production of 123.06 (in 1000 tonnes) and productivity of 26.62 (in MT/hectare) in Tamil Nadu. During the cultivation, the major diseases infecting potato are Early blight (*Alternaria solani*), Late Blight (*Phytophthora infestans)* and Common Scab (*Streptomyces* spp.) which is a threat at high temperatures and wet conditions. *Alternaria* is distinguished by separate conidia borne singly on simple conidiophores. Its spores are elongated, muriform, beaked, septate and dark coloured, while the mycelia are branched and septate. The fungus survives as parasitic and as a saprophytic organism. The first symptoms of early blight appear as small, circular or irregular, dark-brown to black spots on the older (lower) leaves. These spots enlarge up to 3/8 inch in diameter and gradually may become angular-shaped. The annual loss due to *A. solani* is 15-20%. Hence, the management for early blight of potato includes clearing of the infected debris from the field, planting resistant cultivars, spraying of fungicides like azoxystrobin and pyraclostrobin *etc*. All the abovementioned management practices are tedious and have negative impact on environment. Hence, an eco-friendly approach is essential to effectively manage the disease. One such effective biocontrol agent is *Chaetomium globosum* TNAU Cg6, which is an elite strain that has the potential antagonistic activity against a wide range of plant pathogens on the basis of production of diverse metabolites, mycoparasitism, competition for space and nutrients or various combinations. The plant *Eupatorium* is one of the most commonly growing perennial herbs in the hilly region. *E. adenophorum* dried root stems added to the soil in greenhouses have the potential as a bio-fumigant for *M. incognita* management. Hence, in the present study *Chaetomium globosum* TNAU Cg6 and *Eupatorium*

were tested under in vitro conditions. The result of the study showed that the mycelial growth of the pathogen was observed at 14th day after inoculation. TNAU *Cg*-6 recorded the maximum inhibition against pathogen (2.0 cm) with 77.48% inhibition. Under *in vitro, Chaetomium globosum* TNAU Cg-6 was grown on PDA and the ascospores development (44 spores/m^2 in 1 ml of spore suspension) was observed on 8th day after inoculation. The plant herb *Eupatorium* sp. was amended with PDA medium and the *Chaetomium globosum* TNAU Cg-6 was inoculated and maintained in room temperature at 27± 2°C. The tests were conducted in liquid broth with two different treatments *viz*. T_1 - *C. globosum* TNAU Cg-6 challenged with *A. solani* in PD broth alone and T_2- *Eupatorium* amended with PD broth, TNAU Cg-6 challenged with *A. solani*. The result showed that in both the treatments, the initiation of mycelium was first observed in TNAU Cg-6. The maximum inhibition of *A. solani* was observed on 14th day in T_2 treatment.

Keywords: *Chaetomium globosum*, *Eupatorium* spp., *in vitro*

P/3.09

Epidemiological Regulators for Aflatoxin Contamination in Chilli and its Detection

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Chilli is the largest spice crop exported from India as chilli powder, dried chilli, pickled chilli and oleoresins by occupying first position in terms of total exportable value (24.21 %) of 3.00 lakh metric tons to the worth of Rs. 26.91 billions. Chilli, being an important spice crop, is facing twin production problems *viz*. aflatoxin contamination and pesticide residues, which has adversely affected the production of exportable chilli. Aflatoxin produced by *Aspergillus flavus* and *A. parasiticus* is the most potent, dangerous, unavoidable and natural contaminants of food commodities and feed samples at the global level. Aflatoxin is highly hepatotoxic, nephrotoxic, teratogenic and immunotoxic to mammalian system, contaminating cereals (wheat, corn, sorghum, barley and oats), pulses (beans and peas), oil seeds (groundnut, cotton and sesame), fig, vegetable and spices (chilli and onion) *etc*. The present paper describes the serious concern about the role of epidemiological factors on the contamination of chilli fruits and detection of aflatoxin contamination. Among the different epidemiological factors, the optimum temperature required for the maximum growth and excellent sporulation of *Aspergillus flavus* was recorded at 30 °C with 85% relative humidity for maximum growth and 100% relative humidity for excellent sporulation. The good growth of *A. flavus* favours at 27 to 40% moisture content in the chilli fruits, whereas 40% moisture content has shown excellent sporulation. The toxigenic nature of 16 isolates of *A. flavus* was detected and screened by using Indirect Competitive ELISA technique. The maximum aflatoxin B_1 production was recorded in AFL16 isolate (1625.2 µg/kg) indicating the most potent one followed by AFL8 isolate (1081.9 µg/kg) and AFL11 (864.3 µg/kg). On the contrary, AFL 10, AFL14 and AFL6 were non-toxigenic (Produced <40 µg/kg aflatoxin B_1). Thus the availability of toxigenic and non-toxigenic isolates in the same geographical region indicates the existence of natural variance among the *A. flavus* population.

Keywords: Aflatoxin, *Aspergillus flavus*, chilli, ELISA, toxigenic

Theme 4: Postharvest Handling, Value Addition, Utilization and Marketing of Spices and MAPs

Invited Talks

Dr. Vidhi Bapna (Kumath)

Dr. Vidhi Bapna completed her BAMS from Devi Ahilya University, Indore, M.P. during which she received two gold medals. She then did her M.D. in Dravyaguna from Vikram University, Ujjain, M.P. apart from a Certificate Course in Health and Family Welfare Management from National Institute of Health and Family Welfare, New Delhi. She has experience of 22 years in clinical field and 16 years in the field of teaching at UG and PG level. Currently she is working as working as a Professor and Head, P.G. Department of Dravyaguna, J.S. Ayurveda Mahavidyalaya, Nadiad apart from handling the responsibility of Controller of Examination, Maganbhai Adenwala Mahagujarat University. She is working as NAAC steering committee coordinator of her college since June 2019. She is working as official mentor for Medi-Hub Technology and Business Incubation Center, ICAR-DMAPR, Boriavi, Gujarat. She has worked as Course coordinator for 12 batches of 21 days Ayurveda and Yoga training of Aarogya Samanvaya (Department of Public Health, Government of Gujarat) for CHOs during 2019. She is serving as a Scientific Advisor to 'International Ayurveda Foundation' UK, India and Switzerland apart from being a member of Managing Committee of Indian Association for studies in Traditional Asian Medicines. She has completed four research projects and guided 10 research projects of M.D. students as Guide and 5 as Co-guide and 1 EMR project of student funded by SRISTI organization. One Literary research project of CCRAS, India is ongoing. She has delivered 103 lectures as invited speaker/ resource person in various seminars/ conferences/ summer-winter schools/ refresher courses/ SATCOM programs/ webinars etc. She has participated in 91 State/ National /international scientific gatherings and delivered 10 Oral presentations. She has published 30 research papers in peer reviewed journals apart from 33 articles in leading magazines. Dr. Bapna is a co-owner of Green Tree Group Publishers, apart from serving as Chief and Managing Editor of two international journals and newsletter. She also runs her website on Ayurveda (www.liveayurved.com). She received First rank as Mentor in Nutraceuticals Product category at the National Conference and Exhibition sponsored by IKS, Ministry of Education and supported by Ministry of AYUSH at Sage University, Indore, Madhya Pradesh during 2022. She was also felicitated by Young Professional Achievers Award by JCI, Nadiad in 2020.

IT/4.01

Adulterations and Substitutions in Medicinal Plants

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With the increasing popularity and demand of medicinal plants, adulteration and substitution has also increased. Adulteration is a practice of substituting original crude drug partially or wholly with other similar looking substances but later is either free from or inferior in chemical and therapeutic properties. Substitution is when some totally different substance is added in the place of original drug. Adulteration is mostly done for commercial benefit, while substitution may be done because of various reasons like unavailability of the original drug, uncertain identity, controversy regarding the botanical source of drug in various geographical areas, its high price or other reasons. Substitution based on valid reasons and done scientifically may be justified but adulteration in MAPs should not be tolerated. The talk will cover various types of adulteration and substitution with examples, reasons behind adulteration and substitution, perspective of Ayurveda for substitution *etc*. Further, methods to check adulteration and substitution such as morphological, microscopic, physical, chemical, biological evaluation will be discussed along with some case studies for better understanding of the subject.

Keywords: authenticity, drugs, raw material, ayurveda

Dr. K. B. Rameshkumar

K. B. Rameshkumar took his M.Sc. (Chemistry) degree from St. Thomas College, Thrissur in 1997 and joined Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Thiruvananthapuram in 1998 as a scientific staff. He took his Ph.D. (Chemistry) on the topic 'Phytochemical investigation of some Indian medicinal plants' from the University of Kerala, Thiruvananthapuram in 2008. The area of his specialization is Phytochemistry and the current interests are isolation and structure elucidation of secondary metabolites from plants, hyphenated analytical techniques, especially GC-MS and LC-MS, chemistry of essential oils and fixed oils, chemotaxonomy, chemical ecology and herbal technology start-ups. In the tenure of 24 years of research, he has worked on the phytochemistry of several hitherto un-investigated endemic plants of the Western Ghats region and identified new compounds and new natural sources of aromatic and bioactive compounds, in addition to new plant species. He had received the prestigious 'Young Scientist' award by the Govt. of Kerala, K.S.Manilal Award by the Indian Association for Angiosperm Taxonomy, and his students had bagged more than 30 best presentation awards in various seminars. He had also worked in Sultan Quaboos University, Muscat, Oman as a visiting scientist during 2011 and also visited Malaysia during 2013, 2015 and 2018, and Sri Lanka in 2018. He had organized around 50 training programmes, workshops and seminars in phytochemistry related fields, and delivered 60 invited lectures including International Seminars abroad. He was the organizing secretary of the International Seminar on Phytochemistry from 2015 onwards. He had published 60 research papers with a total impact factor ~100, and 2 books on Phytochemistry of Garcinia species, and Cyperaceae species, in addition to more than 120 abstracts in seminar proceedings, and has an H index of 17. He had produced 5 PhDs and supervised 30 M.Sc. students for dissertation. He is a member of the Board of Studies in Chemistry, Mar Ivanios College, Thiruvananthapuram, Executive Council Member, Society for Ethnobotanists, Kerala Chapter and Member, Research Advisory Council, Dale View College of Pharmacy, Thiruvananthapuram. He is also continuing as the General Secretary of Kerala Academy of Sciences, a premier professional body of Scientists and Academicians in Kerala, since 2018. He is the Scientist-in Charge of Central Instrumentation Facility at JNTBGRI, and currently holding the position of Principal Scientist in the Phytochemistry and Phytopharmacology Division of KSCSTE-JNTBGRI, Thiruvananthapuram

IT/4.02

Spices, Aromatic and Medicinal Plants- Phytochemical Perspective and Scope for Herbal Technology Start-ups

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The plant kingdom represents an extraordinary reservoir of molecules that can act as drugs, cosmetics, flavour, perfumes, dyes, natural colourants, pesticides, fuels, food supplements, nutraceuticals, oils and fats. Phytochemistry deals with the diversity of such compounds synthesized from the fascinating laboratory of plants. Out of the diverse plant resources, spices, aromatic and medicinal plants are the resources for a diversity of value- added products and Herbal Technology (HT) deals with the manufacture of value-added products from plant resources. Though our country has rich plant diversity, the floristic wealth is yet to be explored for their potential utility in HT sector. However, the awareness towards natural options in every walk of life has created a new thrust for the plant-based industries globally, and herbal technology is emerging as a new knowledge-based economy sector for India as well. The emerging herbal technology also raises various challenges in R&D field with respect to correct botanical identity, agriculture practices, genetic modifications, development of biomarkers, identification and estimation of active principles, extraction and formulations. Since the ways of utilizing plants and plant products in turn depends on the chemical diversity of the plant, a comprehensive understanding of recent developments in phytochemical techniques are essential in HT. Chemical profiling of the metabolites in plants can be achieved by conventional approaches involving extraction, separation and characterisation, or by using modern hyphenated analytical tools. The rich floristic wealth, combined with the vast traditional knowledge and modern science and technology tools make herbal technology a lucrative sector for future India.

Theme 4: Postharvest Handling, Value Addition, Utilization and Marketing of Spices and MAPs

Oral Presentations

O/4.01

Fostering Agripreneurship in Spices: Role of Agribusiness Incubator

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India has been emerging as an entrepreneurially active nation with entrepreneurship playing significant role in the economy. Business incubators have become an integral part of the support system for the growth of knowledge-based entrepreneurship especially in small and medium entrepreneurial sectors. The Agribusiness Incubator (ABI) of ICAR- Indian Institute of Spices Research is a pioneering incubation centre situated at Kozhikode, Kerala encompassing agri-market oriented development plans that seek to improve farmer's livelihoods through technology commercialization and agri-business incubation. With the ABI's focused efforts, the institute has been able to successfully transfer technologies to responsible companies and startups, thereby making inventions accessible to end users. The ABI was successful in commercializing 105 technologies to 70 firms and was instrumental in establishing 120 successful entrepreneurs across the country and it was also successful in commercializing the technology to a company in Moscow, Russia. Furthermore, to achieve the objective of supporting startup ventures in spice value chain, the ABI has established several state of the art facilities and handholding systems in the institute. Incubation facilities for product development, facilities for white pepper production, black pepper cleaning and grading, curry powder production, seed material storage are well equipped and are available for startups incubated under ABI. Two exclusive spice processing facilities one each for both dry and wet processing of spices with adequate machineries are available for women entrepreneurs and self-help groups under ABI. A mushroom production and training unit is also functioning along with it. A plant nursery for marketing institute varieties and other farmer varieties is being run by ABI for supporting licensees as well as farmers by providing good quality planting materials. Kisan Seva Kendra, which is attached to the plant nursery, is a bio-input resource centre that intends to support small and marginal farmers across the country by facilitating easy access to ICAR technology based agro-inputs at a single place. Pilot facilities for micronutrient and biocapsule production also help the startups for reducing their initial investment risks. A coordinated effort to strengthen the overall marketing of products and services under this umbrella is rooted to an ABI managed sales outlet as well as online platform called Spiisry®. It supports all the stakeholders through active marketing of products and services since the last four years. Overall the ABI has emerged as a key player in driving entrepreneurial and innovative ventures of the institute.

O/4.02

Understanding the Core Principles of Ayurveda for Obtaining Quality Raw Material of Medicinal Plants for Drug Preparation

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Since the commencement of life on Earth, there has been a strong relationship between plants, humans and animals. The history of plant science and the development of Ayurveda, additionally referred to as *Vriksha-Ayurveda*, are intertwined. Primitive knowledge regarding them has been abundant in the *Veda*,

Purana, *Upanishad* and *Brahmana Grantha*. Further, numerous plants have been mentioned in epics like the *Mahabharata* and *Ramayana*. Many Ayurvedic treatises, such as *Brihattrayi*, *Laghutrayi* and *Nighantu Grantha* provide enormous detail on the pharmacokinetics and pharmacodynamics of plants in line with the basic principles of Ayurveda. On the other hand, in the context of agricultural scientific theory, the *Vrikshayurveda* by *Surpala* (c. 1000 AD), *Krishi-Parashara* by *Parashara* (c. 400 BC), *Kashapiyakrishisukti* by *Kashapa* (c. 800 AD) and *Lokopakara* by *Chavundaraya* (c. 1025 AD) have been considered to represent unique literature. Nowadays, demand for plant materials has increased drastically as around the world, people are looking to traditional herbal medicines for their holistic approach to health and wellbeing. Moreover, prices for raw plant materials are always based on the quality of the products. The various methodologies adopted for harvesting play a pivotal role in the quality of the product, price and therapeutic efficacy. The primary aim of this study was to explore the fundamental tenets of Ayurveda regarding the harvesting of medicinal plants through a systematic review of the classical literature. This article contains the applicability of these principles for obtaining quality plant material by implementing Good Agricultural and Collection Practices (GACP) for conducting, Good Manufacturing Practices (GMP) of Ayurveda, Siddha, and Unani (ASU) drugs.

Keywords: Vrikshayurveda, Cultivation, MAPs, technology

O/4.03

Postharvest Studies in *Terminalia arjuna*: Effect of Bark Age on Quality and Market Sample Evaluation

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Terminalia arjuna is a deciduous and evergreen tree of Combretaceae family, growing up to 20–30 m. The plant has shown most promising and distinct results for lipid lowering and cardioprotective activities. The bark stem powder of this tree has been mentioned to be useful for '*hritshool*' (angina) and other related cardiac disorders by the ancient physicians. The secondary metabolite production in plants is affected by many parameters such as plant age, species, biotic and abiotic stresses, location, temperature, water availability *etc*. Also the evaluation of market samples of bark is important to understand the quality of raw material available for public use. Thus, the present study was divided into two parts i.e. a) postharvest quality evaluation of bark from trees of various age groups and b) quality evaluation of market samples of bark collected from different locations throughout India. In the first part *T. arjuna* trees of three different age groups were evaluated for total phenols, total tannins and antioxidant potential. As the age increased, total phenols, tannins and antioxidant activity showed increment. Such study will help to identify the right season and age for harvesting the bark from the tree when the active phytoconstituents are highest in concentration. In the second part of investigation, 77 market samples were evaluated for authenticity using arjunetin as marker. In many cases, gallic acid and ellagic acid are used as marker compound for identification of *T. arjuna*, which are common phenolic acids present in many and hence their utility is questionable. In view of this, a simple, cost effective and rapid thin layer chromatographic method (TLC) was developed using arjunetin as marker compound. 14 out of 77 samples were found to be spurious using this method. The method is useful for quick evaluation of authenticity of crude drug without use of sophisticated method.

Keywords: adulteration, Arjuna, quality, TLC, total phenols

O/4.04

Pluripotent Effect of Turmeric Rhizome Powder in a Pig Model

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The pluripotent effect of turmeric (*Curcuma longa*) rhizome powder (TRP) supplementation in Andaman pigs was evaluated. A total of 48 pigs were randomly allotted into four groups and fed diets containing TRP at 4 concentrations; that is 0, 0.05, 0.10 and 0.2% for 30 days. After 30 days of supplementation, body weight of pigs supplemented with 0.1 % and 0.2 % TRP differed significantly compared to the control group ($p<0.05$), which indicated the effect of TRP as digestive enhancer. Effect of TRP supplementation also indicated protective role on liver because of decrease in serum concentration of aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP). Decrease in serum lactate dehydrogenase (LDH) and creatinine kinase in turmeric supplemented groups indicated potential role of turmeric in preventing tissue damage and protective role on liver and muscle. There was also decrease in cardiac risk factor (CRF) and atherogenic index (AI) in TRP supplemented groups compared to pigs fed only with basal diet. These two indices are potent biomarkers to predict the risk of atherosclerosis and coronary heart disease. Decrease in CRF and AI by TRP treatment is a valuable recommendation for human to prevent cardiovascular disease (CVD), a leading cause of death. Further, supplementation of TRP increased level of antioxidants compared to control group and proved its beneficial role as a potent antioxidant in growing pigs. Anti-inflammatory potentiality of TRP could also be appreciated since TRP supplementation down regulated expression of IL-6, IL-1β and IFN□. Therefore, we perceive that, this conflated approach is an example of its own kind to focus on modification of health status of pigs for more productivity and as translational research on utility of turmeric for possible benefits on human health as growth promoter, antioxidant, anti-inflammatory and to avoid the risk of cardiovascular diseases.

Keywords: Andaman pigs, antioxidant, cardiovascular disease, cytokine, hypolipidemic

O/4.05

Medicinal and Other Uses of Plants by Karen Community in Andaman and Nicobar Islands

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The Karen community of Andaman and Nicobar Islands is known for their traditional knowledge particularly in the field of herbal medicine and artifacts. They came to India for the first time as labourer in 1925 from Myanmar and got settled in the islands. At present, total population of the community in the islands is around 3,000 and they are settled in 9 villages of North and Middle Andaman in Mayabunder Tehsil (7 villages) and Diglipur Tehsil (2 villages). This study was carried out during January to April, 2023 in six villages of Mayabunder Tehsil *viz*. Lucknow (Burmadera), Webi, Karmatang IX, Karmatang X, Lataw and Deopur. Results revealed that a total of 40 medicinal plants species belonging to 27 families are being used by Karen community for treatment of various ailments. The study also revealed seven different species

of plants used for construction, food and artifacts. The most commonly used plants were identified using the Informant Consensus Factor (ICF), Use Value (UV) and Fidelity level (FL). The highest ICF value of 0.94 was observed for *Millingtonia hortensis* and *Zingiber zerumbet*, which are mostly used for food poisoning and bone fracture, respectively. By careful evaluation of data obtained through field visits, interview, ICF, UV and FL, it was found that the most commonly used plants for medicines were *Millingtonia hortensis*, *Zingiber zerumbet, Curcuma longa, Aframomum melegueta* and *Acorus calamus*.

Keywords: Ethnomedicine, fidelity level, informant consensus factor, use value

O/4.06

Outreach of CIARI Technologies to the Farmers of Andaman and Nicobar Islands with Special Reference to Spices – an Overview

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India is the world's largest producer, consumer and exporter of spices. At national level, the production of different spices reached 10.88 million tonnes in the year 2021-22. As per statistics of Andaman and Nicobar Administration for 2021-22, total production of 984.30 MT is reported from an area of 319.28 ha in the islands. The contributing spice crops production mostly grown as an intercrop under arecanut and coconut are from black pepper (46.39 MT), clove (21.33 MT), nutmeg (0.68 MT), cinnamon (38.54 MT), ginger (472.38 MT), chilli (168.02 MT) and turmeric (236.94 MT) from cultivated areas of 49.92 ha, 8.52 ha, 4.16 ha, 25.78 ha, 109.40 ha, 58.75 ha and 62.75 ha, respectively. The research output and proven technologies of authors' institute were are disseminated to farmers through various extension activities *viz*. capacity building programmes, trainings, demonstrations, field days, Kisan mela, awareness programme and commercialization. A study conducted to assess the extent of adoption of CIARI technologies among the farmers of Andaman and Nicobar Islands since 2017 to 2022 revealed that 59 nos. of potential CIARI technologies comprising from the field of horticulture (49.15%), crop Science (23.73%), fisheries (3.39%), animal Science (6.78%) and natural resource management (16.95%) were adopted by 428 farmers across three districts of Andaman and Nicobar Islands. Among them, 59.11% of the beneficiaries were from South Andaman, followed by North and Middle Andaman (39.72%) and Nicobar (1.17%). A total of seven tehsils were covered through numerous technology applications i.e. in South Andaman (253 nos.), North and Middle Andaman (170 nos.) and Car Nicobar (5 nos.). The technologies in agriculture and allied field having more prominence were scientific goat farming, scientific pig management, mini incubator, tri-model therapy for humpsore, followed by black pepper cultivation in arecanut, blood fruit cultivation, roof-top gardening, CIARI Dhan 5, CIARI Mung 1, CIARI Urd 1, Vermicompost, Homestead IFS and carp feed. Further, the study revealed that, six spices technologies of the Institute i.e. black pepper cultivation in arecanut as intercrop, organic black pepper cultivation, organic ginger cultivation, small scale nursery for herbs and spices, tejpat cultivation and woody pepper cultivation were adopted by farmers for its upscaling. Seeing the market potential and economic returns from the spices of Andamans, efforts are being made by Andaman and Nicobar Administration to take up the cultivation of spices at different locations of the Islands in Mission mode under the technical guidance of ICAR-CIARI, Port Blair and thereby creating a spice hub with market linkage benefiting more Agriprenuers from these Islands and mainland India.

Keywords: Outreach, spices, Andaman, Technologies

O/4.07

Ethno-medicinal plants of Euphorbiaceae used in Andaman and Nicobar Islands

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Euphorbiaceae stands out as the fifth most prevalent plant family in the Andaman and Nicobar Islands, with 139 species spread across 41 genera. Within this relatively compact geographical area of 8,249 square kilometers, this plant family ranks second in the number of endemic species, with a total of 33 unique species. The indigenous tribes of these islands have a long history of using Euphorbiaceae plants for various medicinal purposes. Extensive literature research has revealed that among the 27 Euphorbiaceae plants employed by the island communities, they are utilized to address a wide spectrum of 50 distinct health conditions. Notably, 75.53% of these plant species are incorporated into compound formulations, where two or more plants are combined for therapeutic purposes while 11 plants are employed singularly. Among the various local health traditions (LHTs) practiced, the most prominent applications of Euphorbiaceae plants include their use as analgesics, emetics, and contraceptives. One distinguishing feature of plants of Euphorbiaceae is their rich content of secondary metabolites like triterpenoids, diterpenes, lanosterol *etc*. attributable to the latex they contain. Of note, *Claoxylon indicum* (Reinw. ex Blume) Hassk is the most valued plant within this family, reportedly harnessed for the treatment of an impressive 25 different diseases. Following closely is *Ricinus communis* L., recognized for its efficacy in addressing 20 ailments. Over the last three years, author's institute has collected 58 unpublished LHTs from the indigenous communities, and it's noteworthy that 13% of these traditions involve at least one plant from the Euphorbiaceae family. This highlights the enduring importance of these plants in local healthcare practices. Furthermore, conducting pharmacological studies on these medicinal plants holds promise of developing potential drugs. Such innovations could potentially reduce the strain on endangered plant species often exploited by pharmaceutical companies.

Keywords: Bay Islands, Local Health Traditions, native tribes

O/4.08

Identification of Potent Phytochemicals against *Magnaporthe oryzae* through Virtual Screening and Molecular Dynamics Simulation Approach

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Magnaporthe oryzae stands as a notorious fungal pathogen responsible for causing devastating blast disease in cereals, leading to substantial reductions in grain production. Despite the usage of chemical fungicides to combat the pathogen, their effectiveness remains limited in controlling blast disease. Consequently, there exists a pressing need to discover novel natural biofungicides for efficient blast disease management. In light of this, our study conducted virtual screening to explore the molecular interactions between nineteen plant-derived natural compounds and the effector protein, Avr-Pik. Among the evaluated phytochemicals, calotropin, lupeol and azadirachtin emerged as the top-ranking molecules based on their favourable affinity through molecular docking with the effector. Former two are phytoconstituents of *Calotropis procera* and later

of *Azadirachta indica*, two important Indian medicinal plants. To ascertain the stability and reliability of these compounds, extensive molecular dynamics (MD) simulations spanning 100 nanoseconds were conducted. Through MD simulations and free energy calculations, it was revealed that these selected compounds exhibit stable and favourable energies, thereby establishing strong binding interactions with Avr-Pik. Moreover, in our investigation, these screened natural metabolites were found to meet crucial criteria for fungicide-likeness, including essential absorption, distribution, metabolism, and excretion (ADME) properties, as well as adherence to Lipinski's rule of five. Collectively, our findings strongly indicate that these compounds possess the potential to serve as crucial elements for the development of natural product-based fungicides, targeting the blast fungus. Such biofungicides hold promise for enhancing disease management strategies and mitigating the impact of blast disease on cereal crops.

Keywords: *Magnaporthe oryzae*, molecular dynamics simulation, phytochemicals, *Calotrophis procera*, *Azadirachta indica*

O/4.09

In vitro Antibacterial Activity of Some Medicinal Plants against Bacterial Fish Pathogens

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Plants like *Ehretia laevis*, *Leea indica*, *Tabernamonta crispa* and *Andrographis paniculata* were collected from the Andaman Islands and were subjected to ethanolic and methanolic extraction. These extracts were subjected to *in vitro* agar well diffusion test against one Gram (+) pathogen- *Staphyloccus warneri* and two Gram (-) pathogens- *Aeromonas caviae* and *Pseudomonas aeruginosa*, which were isolated from disease outbreaks. The agar well diffusion test revealed that 200 µg of ethanolic and methanolic extracts of *E. laevis* demonstrated a zone of inhibition of 12.01±0.1 and 11.7±0.6 mm against *S. warneri*; 18.7±0.6 and 17.7±1.2 mm against *A. veronii* and 14.0 ± 0.0 and 13.3±1.2 mm against *P. aeruginosa*. The ethanolic and methanolic extracts of *L. indica* demonstrated a zone of inhibition of 17.0 ± 0.6 and 16.3 ± 1.2 mm against *S. warneri*, 13.3±0.6 and 12.7±0.6 mm against *A. veronii* and 18.0±1.7 and 18.7±0.6 mm against *P. aeruginosa*. The ethanolic and methanolic extracts of *A. paniculata* demonstrated a zone of inhibition of 18.7±0.6 and 17.7±1.2mm against *S. warneri*, 14.3±0.6 and 13.7±1.2 mm against *A. veronii* and 12.7±1.2 and 12.3±0.6 mm against *P. aeruginosa*. The ethanolic and methanolic extracts of *T. crispa* demonstrated the highest zone of inhibition compared to other plant extracts which is 20.7±0.6 and 21.7±0.6 mm against *S. warneri;* 16.7±0.6 and 13.3±0.6 mm against *A. veronii* and 21.3±0.5 and 20.3±0.6 mm against *P. aeruginosa*. The study revealed that *E. laevis*, *L. indica*, *A. paniculata* and *T. crispa* can be effectively used in treating fish diseases caused by Gram (+) and Gram (-) pathogens, comparable to the antibiotics streptomycin (200 µg) and oxytetracycline (200 µg), which were used as positive control.

Keywords: Medicinal plants, Herbs, Phytotherapy, Fish diseases, Andaman Islands.

Theme 4: Postharvest Handling, Value Addition, Utilization and Marketing of Spices and MAPs

Poster Presentations

P/4.01

Flavor Characterization of Milk Pudding Added with Cashew Nut Testa Polyphenols and Cardamom Oil, Evaluation of Physicochemical and Antioxidant Properties

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Milk pudding containing phenolic extract of cashew nut testa (CNT) and cardamom oil was formulated. CNT is a by-product of the cashew industry and is rich in polyphenols. Both the samples and control were stored for 7 days at 4 ºC. Physicochemical characterization and sensory analysis of the fresh and stored samples were carried out. The results indicated that the sensory quality of the sample did not differ significantly between the test samples (0.04% CNT) and the control, and the sensory quality of the sample remained acceptable after storage. There was no significant change in the pH and fat content of the fresh and stored samples. However, a slight reduction in the L* value of the pudding was observed after 10 days of storage at 4 ºC. HPLC analysis identified (+)-catechin, (-)-epicatechin and catechin gallate as the major phenolic compounds in CNT, which were also detected in the milk pudding. The major volatile compounds in cardamom oil identified by GC-MS were 1,8-cineole (52%), α-terpinyl acetate (36.95%), linalool (0.33%), and β-phellandrene (4.09%). The milk pudding exhibited a dose-dependent increase in its DPPH radical scavenging activity. Overall, the addition of CNT extract and cardamom oil improved the shelf-life of the pudding.

Keywords: By-product, essential oil, storage, value addition

P/4.02

Bioactive Compounds and Antioxidant Capacity from Different Fruit Extracts of Aonla (*Emblica officinalis* Geartn.)

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Aonla (*Emblica officinalis* Geartn.), also known as Indian gooseberry, is distributed throughout the semi-arid region of northern Madhya Pradesh, Rajasthan, plains of Uttar Pradesh, valleys of the Himalayas and tropical southern parts of India. Aonla fruits possess significant nutraceutical properties due to which it is commercially utilized in Ayurvedic preparations. The present study was conducted to access the nutraceutical potential of different extracts of fruit pulp powder of a local variety of aonla. Different extracts of fruit pulp powder *i.e.*, pure methanol, 80% ethanol and ethanol: ethyl acetate: water (4:3:3) were prepared and analyzed for their bioactive compounds and antioxidant capacities. Results showed that extraction yield (1.82%) and tannin content (243 mg/100g) were maximum in extract prepared using methanol followed by that in ethanol: ethyl acetate: water (4:3:3). However, the highest amount of total phenols (587.5 GAE mg/100g), total flavonoids (73.43 QE mg/100g), alkaloids (3.25 AE mg/100g) and ascorbic acid (392.7 mg/100g), along with the highest DPPH radical scavenging activity (91.2%) and FRAP (92.7%) were recorded in the

extract prepared from ethanol: ethyl acetate: water (4:3:3) solvent followed by that from 80% ethanol except for the alkaloids content, which was the highest in methanolic extract.

Keywords: DPPH, FRAP, Indian gooseberry, nutraceutical, *Phyllanthus emblica*, solvent

P/4.03

Synergistic Use of Medicinal Plants Extracts to Combat the Resistant Mastitis Causing Bacterial Pathogens

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Inflammation of the mammary glands in cattle and buffaloes is known as mastitis, and it is an important problem from an economic standpoint. Physiological, chemical, microbiological, and pathological changes in the udder and milk are signs of mastitis, which affect both the quantity and quality of milk produced. The three main pathogens responsible for bovine mastitis are *Streptococcus* spp., *Staphylococcus aureus*, and *coliform* bacteria. Antimicrobial resistance (AMR) is a serious public health issue that affects both human and animal health, food security, and overall development of animal husbandry sector. These pathogenic bacteria have developed a variety of resistance mechanisms against several antibiotics. Hence, the search for medications made from medicinal plants has been intensified to stop the spread of resistant pathogenicity among bacterial species. To tackle resistant *S. aureus* strains, new antimicrobials in the form of phytochemicals have been instrumental. It has been discovered that several medicinal plants are beneficial against the pathogens that cause mastitis. *Phyllanthus embilica*, *Ocimum basilicum*, *Murraya koenigii*, *Mentha piperita*, *Eucalyptus teriticornis*, *Berberis aristata* and *Berginia legulata* have shown antibacterial activity against resistant strains of Gram positive and Gram-negative bacteria. Ethanolic and methanolic extracts of these plants have shown significant synergistic effect with antibiotics such as gentamicin, oxacillin, tetracycline, kanamycin and erythromycin. Essential oil derived from leaves of eucalyptus is rich in phytochemicals like eucalyptol, eudemon, terpineol and showed antibacterial activity against methicillin resistant *Staphylococcus aureus* (MRSA) and extended spectrum beta lactamase (ESBL) strains of bacteria. Geraniol and n-octyl acetate in *Ocimum basilicum* were observed to be effective antimicrobial agents against resistant Gram positive and negative bacteria. Similarly, flavonoids, phenolics and tannins obtained from organic solvent extracts of *Murraya koenigii* leaves were observed to form zone of inhibition against pathogens. Thus, medicinal plants have tremendous potential to inhibit antibiotic resistant bacteria causing mastitis in dairy animals.

Keywords: *Escherichia coli*, *Staphylococcus aureus*, ESBL, MRSA, AMR

P/4.04

Studies on Blended Bar from Nutmeg (*Myristica fragrans* Houtt.) Rind Residue and Mango Pulp

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Nutmeg (*Myristica fragrans* Houtt.) is one of the important tree spice crops belonging to the family Myristicaceae. The present experiment on value addition in nutmeg was carried out at Department of Post Harvest Technology, College of Horticulture, Dr. BSKKV, Dapoli during 2021-2022. Nutmeg rind residue was blended with mango pulp in different combinations to prepare blended bar, which was compared with that prepared from nutmeg rind residue alone. Four treatments *viz*., T_1 (100% nutmeg rind residue), T_2 (75% nutmeg rind residue + 25% mango pulp), T_3 (50% nutmeg rind residue + 50% mango pulp) and T_4 (25% nutmeg rind residue +75% mango pulp) were replicated five times. The prepared products were analyzed for changes in their chemical composition, microbial safety and sensory quality at 2 months' interval up to 6 months and cost of production was also calculated. Results revealed that during storage, total soluble solids content, titratable acidity, total sugars, non-reducing sugars, tannins, and vitamin A were found to decrease during storage while reducing sugars increased. After six months of storage, product from T_4 showed the highest TSS (71.20 ºBrix), total sugars (58.22%), reducing sugars (30.80%), and vitamin A (3331.03 IU/100g), while the highest non-reducing sugars (25.62%), titratable acidity (1.23%) and tannins (48.80 mg/100g) were recorded in T_1. Product from the treatment 3 recorded the highest sensory scores for colour (7.58), texture (7.53), flavour (7.59), and overall acceptability (7.50). In microbial studies, the lowest bacterial count (0.7 cfu/ml) was recorded in T_1, while T_3 exhibited lowest fugal count (0.8cfu/ml) at the end of 6 months of storage. T_1 and T_2 recorded the highest benefit cost ratio of 1.46.

***Keywords:** Blending, by-product, microbial analysis, sensory quality

P/4.05

Development and Evaluation of Syrup from Nutmeg (*Myristica fragrans* Houtt.) Rind

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Nutmeg rind is a by-product from nutmeg plantations, which is rich in nutrient but cannot be consumed as such due to high acidity, poor taste and flavour. To resolve the issue, an experiment was conducted to prepare syrup from it. The experiment was carried out at the Department of Post Harvest Technology, College of Horticulture, Dr. BSKKV, Dapoli during 2021- 2022. The experiment was designed in completely randomized design with four treatments *viz*., T_1- (25% juice +75% sugar), T_2- (30% juice +70% sugar), T_3- (35% juice + 65% sugar) and T_4- (40 % juice + 60% sugar) and each treatment was replicated five times. The prepared product was analyzed for changes in its chemical composition, microbial safety and sensory quality during 6 months of storage. Study revealed that the highest TSS (76.4 ºBrix), total sugars (65.50%),

non-reducing sugars (27.43%), and lowest pH (2.93) were recorded in T_1, while T_4 recorded highest reducing sugars (47.35%), titratable acidity (0.88%) and tannins (82.4 mg/100g). Treatment 3 recorded highest sensory scores for colour (8.22), flavour (8.36), and overall acceptability (8.29) at the end of storage. Treatment 4 had the lowest bacterial count (0.8 cfu/ml) and treatment 1 had lowest fugal count (0.4 cfu/ml) at the end of 6 months' storage. For cost of production, treatment 2 recorded the highest benefit cost ratio of 1.46 followed by T_3 (1.40).

Keywords: Beverage, reducing sugars, rind, storage

P/4.06

Decoding Market Behaviour for Black Pepper Farmers: Exploring Temporal Trends and Seasonal Dynamics

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Commercial significance of Indian spices including black pepper, becomes evident in their role as catalysts for the discovery of an exclusive sea route connecting Europe to India around 600 years ago. Though Indian black pepper is renowned for its superior quality, a significant majority of pepper farmers overlook the potential to capitalize on this opportunity, and instead opt to sell their produce during the post-harvest glut. Unlike other perishable agricultural products, farmers can store black pepper for extended periods, up to three years, enabling them to choose the optimal marketing time based on prevailing prices. Considering these aspects, this study aimed to identify the month(s) that would be most profitable for farmers to sell their black pepper. For this purpose, the study used a long-term market data (April 2002 to July 2023; 9,457 daily records) for a major market (Sirsi, Karnataka), collected from the Department of Agricultural Marketing, Govt. of Karnataka. Data on daily modal prices and market arrivals were converted to monthly average prices and cumulative arrivals, and subjected to outlier treatment. Using SPSS, data were subjected to seasonal decomposition using multiplicative approach, decomposing the series (price and arrivals) into its constituent components: combined trend and cycle component, seasonal component and remainder (residual) component. The peak harvesting season of black pepper is from December to February. The months of December (167.6%), January (161%), February (169%) and March (122.1%) registered higher seasonal factors in market arrivals ($\chi 2 = 32.16$, $p<0.01$). In contrast, period from April to November demonstrated subdued seasonal effects, with lowest during October (57.1%). However, prices exhibited opposite patterns: May to October months registered higher than average seasonal prices and November to April months exhibited lower prices. Analysis revealed that prices were the lowest in March (97%) and the highest in August (103%). These findings not only highlight the temporal dynamics of black pepper prices and arrivals but also offer insights for farmers, enabling them to optimize decision-making.

Keywords: Marketing, market intelligence, seasonal decomposition, seasonal factor, time series analysis

P/4.07

Studies on Phytochemical Composition, Antioxidant Activity and Efficacy of Crude Extracts of Therapeutic Medicinal Plant- *Zanthoxylum rhetsa*

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The precious wealth of traditional knowledge pertaining to health care has been an asset for our country. However, utilization of modern science and technological advancements for transforming this asset to resources for prosperity and sustainability is required. *Zanthoxylum rhetsa*, an indigenous spice, has been traditionally used in health care system in Manipur. Crude extract of wild fruits and seeds contained several phytochemicals including antioxidants, alkaloids, saponins, tannins, flavonoids and phenols to the tune of 570.0 µg/ml, 50.2 mg/g, 56.0 mg/g, 19.5 mg/g, 8.8 mg/g and 7.5 mg/g, respectively besides minerals like potassium (21.2 mg/g), nitrogen (17.2 mg/g) and phosphorous (2.21 mg/g). Value addition in this ethnomedicinally important plant could yield valuable dietary supplements, prophylactic and therapeutic medications. For confirmation of its antimicrobial efficacy, it was tested against the *Staphylococcus aureus*, *Pseudomonas aeruginosa, Pseudomonas putida, Klebsiella pneumoniae and Escherichia coli.* The results revealed species specific antimicrobial activity of *Z. rhetsa*.

Keywords: Antimicrobial activity, minerals, phytochemical constituents

P/4.08

Phytochemical Analysis and Antioxidant Activity of Different Solvent Extracts of *Knema andamanica* (Warb.) W.J. de Wilde

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Knema andamanica is a red-listed species belonging to the family Myristicaceae, distributed in Andaman and Nicobar Islands, Malaysia, Indonesia and Thailand. Myristicaceae is considered as one of the most primitive family with remarkable phytochemical properties and biological activities. *K. andamanica* is used in tribal medicines to cure cough and throat pain and as a blood coagulant. The present investigation is focused on the preliminary phytochemical analysis and antioxidant properties of leaf extracts of *K. andamanica* prepared in different solvents including hexane, acetone, methanol and water. The analysis revealed the presence of alkaloids, steroids, terpenoids, phenols, flavonoids, saponins, glycosides, tannins, phytosteroles, triterpinoids, diterpenes, lignins, phlobatatannins, gums and mucilages in different solvent extracts. Phenols, alkaloids and tannins were the major phytocompouds present in different extracts. Methanol and acetone extracts showed the presence of maximum phytochemicals. Antioxidant property of hexane, acetone, methanol and water extracts was tested using five assays namely total antioxidant, ABTS, hydroxyl, superoxide and nitrous oxide. Gallic acid and Ascorbic acid were used as the standard. The methanolic extracts possessed lower IC_{50} value with higher antioxidant property than the other extracts. The IC_{50} values

of methanolic extract were found to be 452.99, 425.90, 741.87, 750.07 and 758.06µg/mL in total antioxidant, ABTS, hydroxyl, superoxide and nitrous oxide assays, respectively. Phytochemical and antioxidant activity analysis demonstrated the plant to be a rich source of secondary metabolites.

Keywords: Andaman and Nicobar Islands, antioxidant, Myristicaceae, vulnerable

P/4.09

Effect of Postharvest Treatment and Storage Environment on Shelf-life, Quality and Colour Values of Curry Leaf var. Senkambu

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Pre and post-harvest application of hexanal as enhanced freshness formulation (EFF) has been found to be effective against premature fruit drop, superficial scald and fungal infection in the harvested produce. EFF has also been reported to increase fruit firmness, quality, freshness, and fruit retention in various fruit and vegetables. The effect of EFF as postharvest treatment on shelf- life enhancement in curry leaf is not well known. Therefore, the present study was conducted to determine the effects of post-harvest application of hexanal on shelf life of curry leaf cv. Senkambu under two different storage environments. The treatments included dipping of curry leaf in EFF solution of three different concentrations *i.e.* 1% (T_1), 2% (T_2), 3% (T_3), water dip (T_4) and control-without any dip (T_5). Curry leaves were treated with EFF for 2 minutes and the treated produce was air-dried. Samples were stored under ambient condition (28°C ± 2°C, 60 ± 10% RH) and cold room condition (13°C ± 2°C, 90 ± 5% RH). In cold storage, the stored lot was divided into two groups; one packed in polythene cover of 100-gauge thickness and another, without any cover. Among the treatments, T_2 recorded minimum physiological loss in weight (PLW), which was on par with T_1 and T_3 for 2nd and 3rd day after storage. In cold storage, the treatment T_2 recorded 1.43, 1.98, 2.85, 3.96 and 4.27 per cent weight loss, respectively, during the five days' storage period, which was the minimum among all the treatments. Treated and untreated curry leaf packed in polythene cover and stored under cold storage showed minimum weight loss for the entire storage period. The treatment T_1 recorded 0.71 per cent for 2nd to 5th DAS and on 6th day it was 1.85 per cent followed by T_2 and T_3 registered 1.43 and 1.32 per cent PLW, whereas T_4 accounted for 0.65, 0.74, 0.85, 0.89, and 1.43 per cent and T_5 (control) recorded 1.50, 1.90, 2.50, 2.90 and 4.28 per cent PLW from 2nd to 6th DAS. There was no significant difference among the treatments for total chlorophyll content of the leaves, which ranged from 0.48 mg/100 g (T_5) to 0.60 mg/100 g (T_1). However, chlorophyll content ranged from 0.17 mg/100 g (T_5) to 0.29 mg/100 g (T_3) in produce stored in cold storage in polythene cover. Significant differences were observed for total iron content of the leaves stored in ambient and cold storage. Both treated and untreated samples recorded the colour values of lighter, more green and less yellow except T_3 (b=18.12) than standard (L=64.93, a=0.39, b=16.35). Cold stored samples without pack showed lighter, more green and less yellow except T_2 (b=18.13). Total colour difference (ΔE) was 3.89 in T_5 (control) followed by T_1 (4.10), T_3(5.36), T_2 (5.82) and T_4 (5.92), respectively.

Keywords: Cold storage, EFF, packaging, relative humidity, temperature

P/4.10

Exploration of Endophytic Bacteria Associated with Critically Endangered Medicinal Plant- *Trillium govanianum* Wall. *ex*. Royle

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Trillium govaniaunm is a critically endangered medicinal plant, commonly known as '*Nag Chhatri*', that grows mainly in dry temperate zone of western Himalayas, India. This study aimed to determine the diversity of endophytic bacteria associated with *T. govanianum* and to evaluate their plant growth promoting activities. Three robust endophytic bacteria were isolated and identified from the rhizomes of *T. govanianum* and designated as Ar13, Ar17 and Ms5. The best P-solubilisation (92.56±2.29 µg/mL) and IAA production (62.74±0.58 µg/mL) were recorded by strain Ar13, whereas, the highest siderophore production (94.86±2.02% SU) was recorded in Ms5. The maximum protease activity in terms of zone of inhibition (18.00±0.11 mm) was shown by the strain Ms5, whereas Ar13 showed highest cellulase (20.00±0.41 mm), chitinase (22.00±.02 mm) and ACC deaminase (48.84 ± 0.17 µM ά-KB mg^{-1} h^{-1}) activities. Furthermore, these strains were identified as *Pantoea vagans* Ar13, *Microbacterium phyllosphaerae* Ar17 and *Pseudomonas mandeli* Ms5 by 16S rRNA gene sequencing. The study will hold implications for the development of bioformulations, with a focus on enhancing environmental sustainability.

Keywords: Endophyte, medicinal plant, zone of inhibition

P/4.11

Agarwood Based Economy of North-East India

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Aquilaria malaccensis Lamk., locally known as *xhasi*, agaru or agarwood, is a potential aromatic floral wealth of northeast India. Agar is highly valued for its medicinal, incense, and perfumery properties. The genus *Aquilaria* has 21 species, of which 13 produce agarwood. In India, available genera are *Aquilaria malaccensis* and *Aquilaria khasiana*. Agarwood is a dark brown resinous heartwood formed due to host-fungus interaction, but the process is not yet fully understood. Depending on the oleoresin content, the price of agarwood varies from $20,000-$100,000 per kg. In Northeast India, almost 20 million agar trees are under cultivation of which approximately 5 million trees are naturally infested by a stem borer insect-*Neurozerra conferta*. Infestation primarily occurs in Golaghat, Sivasagar, and Jorhat districts of Assam, and in a few places of Tripura and Nagaland. The remaining 15 million trees require artificial *inoculation*. ICFRE- Rain Forest Research Institute, Jorhat has successfully developed an artificial inoculation technique using fungal culture and validated it in farmer's fields across the northeast India. About 9.5 lakh people are engaged in its cultivation and trade. There are more than 10,000 industries producing agarwood chips and agar oil, and approximately 70,000 farmers and workers are involved in agar business, while another 1.5

lakhs gain from it contingently. The significant importers of agar from India are Kuwait, Saudi Arabia, the UAE, and Singapore. Thus, this export-oriented economy of agarwood provides livelihood opportunities for local people. *Aquilaria malaccensis* is also a potential agroforestry species in homestead gardens. According to some estimates, global market for agarwood chips is expected to grow at 7.2% CAGR to reach US$ 87,467.6 million by the end of 2033. Low input, low maintenance, flexibility in site requirement, improved economic opportunities for people and intercropping opportunities make agar a potential candidate for cash crop in the region.

Keywords: Agarwood, *Aquilaria malaccensis*, artificial inoculation, *Neurozerra conferta*, Northeast India

P/4.12

The Power of *Draksha*: Revealing the Health Benefits

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Draksha (grape), scientifically known as *Vitis vinifera*, is a perennial woody climber belonging to the Vitaceae family. It is also referred to as *Madhurasa* due to its sweet taste, reminiscent of nectar. It has many medicinal and therapeutic properties, due to the diverse phytochemical profile. Grapes are a rich source of polyphenols, including resveratrol, flavonoids, and anthocyanins, which exhibit potent antioxidant, anti-inflammatory, and anti-cancer activities. These compounds work synergistically to combat oxidative stress, reduce chronic inflammation, and mitigate the risk of various chronic diseases, including cardiovascular disorders and certain types of cancer. The fully ripe fruit has diuretic property, aids in weight gain, functions as an aphrodisiac and appetizer, and is good for the throat. It also acts as a laxative and purgative. It can be used to treat illnesses of the blood as well as ailments including thirst, asthma, jaundice, and stranguria. Haemorrhoids, testicular oedema, and joint pain can be treated with the ashes of the stem. The flowers are expectorants, hemotonics and effective in the treatment of bronchitis. Grape leaves are used to treat bleeding and diarrhoea. Flavonoids, polyphenols, anthocyanins, proanthocyanidins, procyanidines, and the stilbene derivative resveratrol are among the active substances found in grape seeds and skin. Notably, grape seed extract has a wide range of pharmacological and therapeutic properties. Ayurvedic medicines that incorporate grapes include Draksharishta, Drakshasava, Drakshadi Kashayam, Manasamitra Vatakam, Drakshadi Vati *etc*. These medicines are useful in cold, cough, asthma, intestinal worms, treating depression, dizziness and anorexia. In conclusion, it is evident that harnessing the power of draksha could offer a delicious and nutritionally potent approach to promoting overall well-being.

Keywords: Grape, nutrition, medicinal value, resveratrol

P/4.13

Importance of Spices and their Value Addition in India: a Review

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Spices and condiments are the primary ingredients in Indian cuisines and also serve as key important constituents in preparation of Ayurvedic medicines. Spices are high value export oriented crops and India is a major exporter of spices and spice products. European and Arab countries are major importers of spices from India. Spices can be used in different forms like fresh, whole dried, or pre-ground dried which require further processing for it to be utilized in the form of value-added products. Standardized processing techniques and value added products from black pepper, coriander, cinnamon, fenugreek, turmeric *etc*. are available. However, development of varieties suitable for processing, good cultivation practices, hygienic harvesting and postharvest handling, and use of suitable packaging material could further ensure the quality of raw material for value addition and niche marketing.

Keywords: Condiments, hygienic, medicinal benefits, postharvest, processing

P/4.14

Contribution of Phytochemicals in Solanaceous Vegetables to Disease Prevention and Immunity Enhancement

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Vegetables are essential for a balanced diet, providing fiber, minerals, vitamins and have different phytochemicals, antioxidants like carotenoids, anthocyanins and alkaloids, which prevent diseases and their proliferation. However, a shift towards dietary habits with reduced consumption of fruits and vegetables, coupled with a sedentary lifestyle, is contributing to a rise in lifestyle-related diseases and conditions such as diabetes, hypertension, hypercholesterolemia, cardiovascular ailments and various forms of cancer. Phytochemicals found in Solanaceae vegetables are believed to play a role in eliminating toxins, scavenging free radicals, repairing damaged DNA and consequently, reducing the risk of cancer. The most prominent phytochemicals found in Solanaceae vegetables, including tomatoes (Lycopene and Quercetin), capsicum (Capsaicin), eggplants (Nasunin), and potatoes (Solanine), exhibit a range of medicinal properties, such as antioxidants, cardiovascular disease prevention, anticancer effects and anti-inflammatory properties. The investigation into the significance of biomolecules in human health has intensified in recent times, surpassing previous levels of research. With the recent advancements in analytical techniques, it is now feasible to investigate the phytochemical composition of fruits and vegetables, uncover their structural and functional properties, and explore their potential in preventing or mitigating numerous Non-Communicable Diseases. This paper provides a concise overview of phytochemicals derived from vegetables and their promising therapeutic applications against different diseases with a main emphasis on cancer. While numerous phytochemicals have been identified, many of their potential benefits remain undiscovered and in need of further exploration. The current research places significant emphasis on studying the phytochemicals present

in vegetables from the Solanaceae family, such as tomatoes, potatoes, eggplants, chili peppers, and black nightshade.

Keywords: Cancer, diseases, phytochemicals, Solanaceae, vegetables

P/4.15

Value Addition of Tamarind (*Tamarindus indica*) as a Viable Entrepreneurship Option

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Tamarind (*Tamarindus indica)* is one of the well-known (tree) spice in India. Its pulp has been used in many traditional medicines as a laxative, a digestive, and as a remedy for bile disorders. This spice is also used as an emulsifying agent in syrups, decoctions *etc*., in different pharmaceutical products. The preservation of tamarind and its processing into value-added products are the most effective ways to preserve the contents of fruits. The storage of tamarind for a long period of time is a problem as many physicochemical changes take place during storage, so the study focused on raw tamarind utilization for the preparation of value-added products. Tamarind fruits are used for making various types of value-added products, which has huge commercial acceptability in the market as well as for health benefits. The market study hinted at the fact that raw tamarind is unprofitable to sell, so the farmers should go for value addition. In the present investigation, different value-added products from tamarind such as squash, pulp paste, jelly and syrup were prepared but among the different value-added products, tamarind paste prepared from 100 g paste + 15 g salt was found superior with respect to sensory quality and microbiological safety. The prepared tamarind paste remained acceptable up to 120 days of storage. Tamarind paste is used in numerous culinary preparations and has a greater demand. The convenience of using tamarind pulp may be enhanced by converting it into paste form. Paste is very easy to prepare with minimal value addition and low expenditure. After being neatly packaged, tamarind pulp paste can be easily handled, used, and transported in areas where tamarind is not grown.

Keywords: Pulp paste, storage, tamarind, value added product

P/4.16

Development and Shelf-life Evaluation of Spice Flavoured Sorghum (*Sorghum bicolor*) Cookies: a Study on Valorisation of Millets for Food Security

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This study evaluated the effect of storage period and packaging materials on the quality attributes of spice-flavoured sorghum millet cookies. Quality characteristics such as moisture content, texture, overall acceptability, antioxidant activity, free fatty acid and peroxide value of gluten-free cookies made from sorghum millet flour were investigated during the storage period under ambient conditions. The result of the study indicated that the moisture content, free fatty acid and peroxide value of developed cookies increased, while hardness decreased with an increase in storage time for cookies packed in both biaxially oriented polypropylene and metallised polyester package. During storage, moisture content increased more in biaxially oriented polypropylene as compared to metallised polyester package. The free fatty acid

and peroxide value of cookies increased in both packaging materials during storage, whereas the highest increase was observed in 120 days of storage. The metallised polyester package was found to be the best packaging material than biaxially oriented polypropylene with respect to sensory, textural and shelf stability characteristics of sorghum cookies.

Keywords: BOPP, metallized polyester, peroxide value, sorghum, value addition

P/4.17

Screening Aonla (*Emblica officinalis* Gaertn.) Cultivars for Value Addition

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Aonla or Indian gooseberry is one of the medicinal fruit crops of commercial importance in Ayurvedic and Unani medicine. For processing, we need to select promising cultivars with best physico-chemical properties. Hence, the present investigation was carried out under laboratory condition during the year 2019-20 to evaluate the aonla cultivars for value addition. Total six cultivars were selected for the preparation of candy, murabba and pickle with four replication and storage studies was also conducted. Physico-chemical and sensory scores were analyzed during the product preparation and storage. Candy and Murabba prepared out of cultivar Chakaiya proved much better with respect to quality parameters studied *viz.* product recovery percentage (69.32 and 68.28%), texture value (5.25 to 4.81kg/cm^2 and 4.64 to 4.30kg/cm^2), TSS (74.57 to 75.50 °B and 74.57 to 75.96 °B), ascorbic acid (255.23 to 250.18 mg/ 100g and 410.99 to 385.19 mg/ 100g), total sugar (68.35 to 69.23 and 53.46 to 55.43%), reducing sugar (37.03 to 37.52 % and 27.25 to 29.02%), non reducing sugar (32.18 to 32.20% and 26.23 to 27.41 %), overall acceptability score (8.73 to 8.95 and 8.24 to 8.35) was highest and showed minimum acidity (0.31 to 0.27% and 0.72 to 0.64%), tannin (0.19 to 0.12% and 1.18 to 1.24 %), pH (2.37 to 3.79 and 2.24 to 2.99), microbial load (0 to 1.1 × 10 ^{4} CFU to 0 to 1.0 × 10^4 CFU) respectively during storage. Same cultivars were also evaluated for pickle preparation the maximum recovery percentage (78.02%), ascorbic acid (498.88 to 495.20 mg/100g) and texture (4.91 to 4.40 kg/cm^2). Acidity (2.74 to 1.32%) and the lowest tannin (2.49 to 1.36%) were obtained in cultivar Krishna. All the qualitative and nutritive parameters proved cv. Chakaiya as significantly superior for candy and murabba preparation and that of NA-4 (Krishna) was suitable for pickle preparation.

Keywords: evaluation, physico-chemical properties, processing, products

P/4.18

Cardioprotective Effects of Functional Smoothie Beverage Supplemented with Double Emulsion Encapsulated *Emblica officinalis*

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Emblica officinalis, called as Indian gooseberry or *amla*, possess high antioxidant activity and is known for multiple health benefits. *Amla* aqueous extract (AME), owing to it's superior antioxidant properties, is considered a suitable ingredient for functional foods preparation to address cardiovascular diseases (CVD).

However, direct addition of AME into food products may lead to loss of bioactivity and cause undesirable changes to food quality. Hence, in the current investigation, AME was encapsulated in water-in-oil-in-water (W/O/W) double emulsion (AMED) for its supplementation in functional foods to avoid losses to bioactivity of AME. The optimized double emulsion was able to load AME @25% w/w with encapsulation efficiency of 95.2 ± 0.04% and it was stable up to one month at refrigeration temperature (6 ± 1 °C). Further, AMED was supplemented in smoothie (@5% w/w) to prepare functional food. The developed functional smoothie (FS) has very good consumer acceptability and had 45 days of storage stability at refrigeration temperature (6 ± 1 °C). *In vivo* animal bioassay experiments indicated that FS feeding to rats enhanced their HDL level; reduced LDL/VLDL level; reduced cardiac degeneration, liver inflammation, urea production and IgG level. FS feeding also improved nitric oxide production and down-regulated the pro-inflammatory cytokines in CVD rats. These results revealed that FS has cardioprotective effects and can be served as a functional food for preventing CVD.

Keywords: Antioxidant, aonla, CVD, value addition

P/4.19

Clitoria ternatea L. Seed Bacterial Endophytes: A Micro-factory of Bioactive Compounds with Sustainable Interventions

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The plant seeds are not only the carriers of genetic material, but they also build a strong association with micro-organisms and carry them to the next generations. The ability of these seed endophytes to produce a wide range of bioactive compounds make them economically important. Medicinal plants are a huge hub for these endophytes. The perennial climber *Clitoria ternatea* L. (butterfly pea) is one such plant that has attracted significant interest primarily based on its agricultural and clinical applications, which range from use as fodder, and nitrogen-fixation in crops to applications in food, cosmetics, traditional medicinal drugs, and as a source of eco- friendly pesticides and insecticides. A total of 14 bacterial endophytes were selectively isolated from seeds of a native *Clitoria ternatea* L. plant. The isolated endophytes belonged to *Bacillus*, *Pseudomonas*, *Staphylococcus* spp. and also few novel spp. were identified. These bacterial endophytes showed antimicrobial properties and the ability to produce bioactive compounds, which helped in plant growth and development. This research will help in limiting the environmental chemical toxic accumulation by the use of such beneficial endophytic bacterial bio-inoculants. This will bring new prospects towards positive agricultural and environmental development.

Keywords: Bacteria, Butterfly pea, climber, medicinal plant

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