

INTERNATIONAL SYMPOSIUM ON SPICES AND AROMATIC CROPS

Spices as Flavours, Fragrances & Functional Foods

ABSTRACTS

 **SYMSAC X 2021**
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09-12 FEBRUARY 2021



Organised by

Indian Society for Spices, Kozhikode, Kerala, India

Directorate of Arecanut & Spices Development, Kozhikode, Kerala, India

Spices Board, Kochi, Kerala, India

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International Symposium on Spices as Flavours, Fragrances & Functional Foods

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S4 P66	Performance assessment of some fennel <i>Foeniculum vulgare</i> mill genotypes in central India	Reena Nair, Pandey S K & Ankita Sharma
S4 P67	Per se performance of ajowan (<i>Trachyspermum ammi</i> L.) genotypes for yield and physiological parameters	Subramaniyan P, Jeeva Jothi L, Sundharaiya K, Shoba N & Murugesan S
S4 P68	Performance of ajwain (<i>Trachyspermum ammi</i> L. Sprague) varieties at varying nitrogen levels on growth and yield under semiarid tropics of Northern Karnataka	Honnappa Asangi, Kattimani K N, Kulkarni M S, Kotikal Y K, Mastiholi A B, Jameel Jhalegar M D & Siddappa R
S4 P69	Performance of ajwain (<i>Trachyspermum ammi</i> L.) genotypes for growth and seed yield	Meena S S, Lal G & Meena M D
S4 P70	Yield and quality enhancement in ajwain (<i>Trachyspermum ammi</i> L.) through integrated nutrient management	Thanuja G S, Srinivasulu B, Yuvaraj K M & Giridhar K
S4 P71	Effect of micro irrigation on yield and economics in fenugreek under various planting patterns	Shivran A C, Kumawat G L, Gothwal D K & Dharendra Singh
S4 P72	Hisar Mathi-425: A high yielding variety of fenugreek	Tehlan S K & Malik T P

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S4 P73	Assessment of genetic variability, heritability and character association in Kalazeera [Bunium persicum(Bioss.) Fedts.]	Khan M H, Mir G Hassan, Dar N A, Alie B A, Qureshi A I M, Dar S A, Lone A A & Ali M T
S4 P74	Seed priming: Innovative way to improve germination and viability of seed spices	Sanket Shete, Mali P C, Khandekar R G & Salvi B R
S4 P75	Performance evaluation of garlic (Allium sativum L.) accessions for high yield under Nilgiris condition	Arumugam T & Anand M
S4 P76	Response of integrated nutrient management on the growth, yield and quality of Kharif onion (Allium cepa L.)	Krishnaprabu S
S4 P77	Studies on evaluation of Aggregatum onion (Allium cepa var. aggregatum) for high yield under Tamil Nadu conditions	Arumugam T, Shoba Thingalmaniyan K & Vanitha A
S4 P78	Studies on canopy management in curry leaf (Murraya koenigii Spreng.)	Jansirani P & V Suresh
S4 P79	Studies on the effect of iron and zinc application for growth and yield of curry leaf (Murraya koenigii Spreng.)	Mohanalakshmi M & Deepika B
S4 P80	Density and Corm Weight Effects on Stigma and Corm yield in Saffron (Crocus sativus L.) Production	Bashir A Alie, Khan M H, Mir G H, Dar N A, Qureshi A M I & Ali M T
S4 P81	Evaluation of saffron clones for higher yield and quality	Khan M H, Qureshi A I M, Alie B A, Dar N A, Mir G Hassan, Dar S A, Lone A A & Ali M T
S4 P82	Influence of integrated nutrient management on stigma and corm yield of saffron (Crocus sativus L.)	Bashir A Alie, Khan M H, Dar N A, Qureshi A M I, Mir G H & Qayoom S
S4 P83	Study on irradiation (gamma rays) and temperature treatments on corm multiplication and floral traits of saffron (Crocus sativus L.)	Khan M H, Qureshi A M I, Dar N A, Alie B A, Mir G Hassan, Dar S A, Lone A A & Qayoom S
S4 P84	Effect of mulching and nutrient management on yield and quality of sweet basil (Ocimum basilicum L.)	Nayana H & Maruthi Prasad B N
S4 P85	Exploring wild relatives of spices from Andaman and Nicobar Islands	Muhammed Nissar V A, Joseph John K, Pradheep K, Jaisankar I, Jerard B A & Rema J

No.	Title	Authors
S4 P86	Macro and micro propagation in Embeliaribes Burm.f: A threatened species	Aparna P M, Suryanarayana M A, Rajasekharan P E & Divya R K

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S5 OP2	Are soil available nutrient pools varying by patch (field) scale in Indian cardamom hills?	Muthusamy Murugan, Dhanya M K, Alappan Subbiah, Ashokkumar Kaliyaperumal & Nimisha Mathew
S5 OP3	Current scenario of diseases of nutmeg in Kerala and the ways to tackle the challenge	Beena S, Anita Cherian K, Deep Chandran & Liji K O
S5 OP4	Modified Atmospheric Packaging (MAP) for management of Cigarette beetle (Lasioderma serricorne) in ajwain and cumin seeds	Krishna Kant, Mishra B K, Vishal M K, Saxena S N & Meena S R
S5 OP5	Diversity, abundance, foraging behaviour of insect pollinators and impact of mode of pollination on coriander (Coriandrum sativum L.)	Vikas Bharti, Dilbag Singh Ahlawat, Surender Kumar Sharma & Tehlan S K
S5 OP6	Cumin Cuminum cyminum pollination behavior: A case study	Kakani R K & Solanki R K
S5 OP7	Spice clinic: Going public to provide plant health management services for farmers	Vijayan A K, Dhanapal K, Pradip Kumar K, Shadanaika, Ansar Ali M A, John Jo Varghese, Saju K A, Manoj Oommen, Thiyagarajan P, Joji Mathew & Rema Shree A B
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S5 P2	Evaluation of enriched dairy waste compost as ingredient in potting medium for the production of rooted black pepper cuttings	C K Thankamani, P Saranya, V Srinivasan, C Sarathambal, S Shanmugavel, T Athira & K Jayarajan

No.	Title	Authors
S5 P3	Evaluation of local black pepper (<i>Piper nigrum</i> L.) Accessions under Assam condition	Singh L S, Niral V, Anok Uchoi, Alpana Das & Acharya G C
S5 P4	Evaluation of Piper (<i>Piper spp.</i>) rootstocks against slow wilt disease of black pepper (<i>Piper nigrum</i> L.)	Chinnapappa M, Ramar A, Vetrivelkalai P & Kavitha P S
S5 P5	Morpho-molecular characterization of <i>Athelia rolfsii</i> an upcoming pathogen challenging black pepper nurseries	Rashmi C R, Anita Cherian K, Milsha George, Liji K O & Anjali V A
S5 P6	Performance of bush pepper under the forest canopy in combination with high value crops	Bini Sundar S T & Jaya Jasmine A
S5 P7	Ready to use neem oil-garlic-SOAP – an effective IPM against black pepper stem mealy bug	Yamini Varma C K, Neema V P, Ajith P M, Airina C K & Divya K K
S5 P8	Studies on floral traits and reproductive strategy in cultivated <i>Piper nigrum</i> L.- various degrees of dichogamy and herkogamy are discovered	Hassan S & Babu K N
S5 P9	Studies on microbial contamination in stored black pepper	Kripa Theresa P M, Vijayan A K, Saju K A, Gopakumar K & Rema Shree A B
S5 P10	Studies on pre and post infection management efficiency of fungicides against <i>Phytophthora capsici</i> in black pepper	Rini C R, Remya J & Dhanya M K
S5 P11	Studies on the response of black pepper varieties for propagation by serpentine layering	Adarsh Thapa & Suchand Datta
S5 P12	Study on utility of different multipurpose trees as black pepper standards in lateritic soil of Uttara Kannada district	Venkatesh L, Kannur S S & Manju M J
S5 P13	Composition and characteristics of bulk soil microbial communities of cardamom plantations in Idukki, Kerala	Saju K A, Manoj Oommen, Bhagyalekshmi R, Vallath A, Divya P Vijayan, Varsha Sai, Renjitha P R, Binduja Vinod, John Jo Varghese & Vijayan A K
S5 P14	Delineation of cardamom production zone beyond boundaries based on climate analogues	Faras Bin Muhammed, Swetha Sudhakaran V, Krishnamurthy K S, Kandiannan K, Alagupalamuthirsolai M & Jayarajan K

No.	Title	Authors
S5 P15	Evaluation of small cardamom (<i>Elettaria cardamomum</i> Maton.) hybrids for yield and rhizome rot resistance	Akshitha H J, Mohammed Faisal Peeran, Sharon Aravind & Balaji Rajkumar M
S5 P16	First report of <i>Marasmiellus</i> sp on small cardamom <i>Elettaria cardamomum</i> (L.) maton and its in vitro management	Dhanya M K, Murugan M, Neenu T T, Bisnamol J, Doncy S P, Rini C R, Ashokkumar K & Nimisha M
S5 P17	Management of pseudostem rot disease of small cardamom through fungicides and bio-agents	Shivaprasad M, Vinay J U, Swamy A V, Rashmi C & Shilpa M
S5 P18	Phoma sp., A new threat to small cardamom [<i>Elettaria cardamomum</i> (L.) Maton]	Dhanya M K, Murugan M, Neenu T T, Bisnamol J, Doncy S P, Surya R, Ashokkumar K, Nimisha M & Alan C A
S5 P19	Plant morphological traits associated with field resistance to cardamom thrips <i>Sciothrips cardamomi</i> in cardamom <i>Elettaria cardamomum</i>	Jacob T K, Senthil Kumar C M, Devasahayam S, Sharon D'Silva, Senthil Kumar R, Biju C N, Praveena R & Ankegowda S J
S5 P20	Studies on microbial contamination in stored small cardamom	Sreeparvathy, Vijayan A K, Saju K A, Gopakumar K & Rema Shree A B
S5 P21	Studies on leaf blight disease of large cardamom caused by <i>Colletotrichum gloeosporioides</i>	Dhanapal K, Vijayan A K, Saju K A, Gudade B A & Rema Shree A B
S5 P22	Association of two novel viruses with chlorotic fleck disease of ginger	Bhat A I, Naveen K P, Pamitha N S & Pant R P
S5 P23	Comparative analysis of host-virus interaction deduced through symptomatology, physiological alterations and detection of viruses in ginger (<i>Zingiber officinale</i> Rosc.)	Biju C N, Ishwara Bhat A, Naveen K P, Prasath D, Krishnamurthy K S, Srinivasan V & Hamza S
S5 P24	Development of native bacterial antagonist for the management of <i>Pythium</i> rhizome rot in ginger (<i>Zingiber officinale</i>)	Alex John
S5 P25	Effect of insecticides against shoot borer, <i>Conogethes punctiferalis</i> in ginger	Irulandi S, Anitha T & Manivannan M I
S5 P26	Evaluation of organic amendments for the management of shoot borer, <i>Conogethes punctiferalis</i> and rhizome rot on ginger	Irulandi S, Anitha T & Manivannan M I
S5 P27	Impact of good agriculture practices on eco-friendly and sustainable production of ginger	Nagarajappa Adivappar, Mohankumar H D, Sharanabasappa & Sudeep H P

No.	Title	Authors
S5 P28	Influence of priming in ginger (<i>Zingiber officinale</i> Rosc.) transplants	Dharini Chittaragi & Jalaja S Menon
S5 P29	Organic cultivation of ginger as a intercrop under coconut plantation - A viable option to the farmers of Andaman and Nicobar islands	Damodaran V, Abirami K & Augustine Jerard B
S5 P30	Performance evaluation of high yielding ginger (<i>Zingiber officinale</i> Rosc.) varieties under organic nutrition for sustainable farming	Bindu B
S5 P31	Rhizosphere priming effect on nutrient mineralization dynamics of crop residues in ginger	Srinivasan V, Dinesh R, Mohammed Thanveer P, Alok Tiwari & Hamza S
S5 P32	Yield and nutrient uptake of ginger (<i>Zingiber officinale</i> Rosc.) as influenced by organic manures and Bio-stimulants	Chitra R & Vinothini L
S5 P33	Distinctiveness, uniformity and stability (DUS) characters of turmeric (<i>Curcuma longa</i> L.) germplasm	Suresh R, Ramar A, Senthamizh Selvi B & Rajeswari S
S5 P34	Effect of chemical weed management on growth, yield and economics of transplanted turmeric	Shalini R M, Srikantaprasad D, Pushpa T N, Shwetha Desai & Asha M R
S5 P35	Evaluation of promising turmeric genotypes for Andhra Pradesh	Giridhar K, Suryakumari S & Hariprasad Rao N
S5 P36	Evaluation of turmeric for tolerance to foliar diseases	Anamika Debnath, Sekhar Bandyopadhyaya, Ramkrishna Sarker & Suchand Datta
S5 P37	Increasing productivity of turmeric (<i>Curcuma longa</i>) through organic nutrient management and variety in north east India with special reference to Arunachal Pradesh	Ps Mariam Anal
S5 P38	Management of leaf blotch disease of turmeric	Mishra A K & Singh S P
S5 P39	Management of root-knot nematode, <i>Meloidogyne incognita</i> infecting turmeric (<i>Curcuma longa</i> L.) under coconut cropping system	Rajkumar, Rashid Pervez, Santhosh J Eapen & Surekha R
S5 P40	Performance of turmeric cultivars for growth and yield attributes under rain-fed Jammu subtropics	Sandeep Chopra, Samnotra R K, Gupta R K, Manoj Kumar & Satesh Kumar

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S5 P41	Physiological changes in turmeric genotypes subjected to water stress	Nazmin Banu C V & Krishnamurthy K S
S5 P42	Response of turmeric transplants (<i>Curcuma longa</i> L.) to fertigation system	Sangeetha K S & Suresh J
S5 P43	Response of turmeric varieties to organic farming under humid tropics of Kerala	C K Thankamani, V Srinivasan, S Hamza, R Dinesh, R Praveena, C Sarathambal, S Shanmugavel, O Shajina & T Athira
S5 P44	Root lesion nematodes (<i>Pratylenchus</i> spp.) emerge as a serious soil-borne pest across turmeric growing states of India	Sellaperumal C, Santhosh J Eapen & Praveena R
S5 P45	Yield loss assessment by linear regression model and effect of Plant growth promoting Rhizobacteria (PGPR) growth, yield and foliage disease suppression in turmeric (<i>Curcuma longa</i> L.)	Ajit Kumar Singh & Shrikant Sawargaonkar
S5 P46	Adaptation strategy to combat climate change effect on chilli production over Tamil Nadu	Kowshika N, Panneerselvam S, Jagannathan R, Geethalakshmi V, Arumugam T & Jagadeeswaran R
S5 P47	Effect of Plant growth promoter on growth and yield of chillies (<i>Capsicum annum</i> L) cv. PKM 1	Janaki D, Poorniammal R, Rajangam J & Kannan J
S5 P48	Improvement of Ramnad mundu/Gundu chilli (<i>Capsicum annum</i>) under rainfed condition for yield and quality	Phani Kumar J, Paramaguru P, Arumugam T, Manikanda Boopathi N & Venkatesan K
S5 P49	Influence of humic acid and biofertilizers on growth, yield and quality of Chillies (<i>Capsicum annum</i> L) var PKM 1	Janaki D, Poorniammal R, Rajangam J & Kannan J
S5 P50	Population dynamics of aphids on Bhut jolokia (<i>Capsicum chinense</i> Jacq.) and evaluation of IPM modules against it in Assam, NE India	Bora S S, Saikia D K, Gudade B A, Deka T N & Rema Shree A B
S5 P51	Responses of exotic hot pepper lines to challenge inoculation of chilli leaf curl virus (ChLCV)	Ganesh Prasad, Balaraju Susmitha, Channabasava, Siddu B C, Mohan Rao A, Nagaraju N & Ramesh S
S5 P52	Classificatory Characterization of some nutmeg (<i>Myristica fragrans</i> Houtt) genotypes	Adavi Rao Desai

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S5 P53	Identification and characterization of Lasiodiplodia theobromae associated with die-back and decline disease of nutmeg	Biju C N, Fadla Basima, Jeevalatha A, Peeran M F, Suseela Bhai R, Muhammed Nissar V A, Srinivasan V & Lijo Thomas
S5 P54	Influence of genotypes on flower production in nutmeg (Myristica fragrans Houtt.)	Sharon Aravind, Kandiannan K, Rema J & Ankegowda S J
S5 P55	Studies on leaf rot of nutmeg caused by Cylandrocladium scoparium	Divya P Vijayan, Vallath A, Pandithurai G, Easwaran V M, Saju K A, John Jo Varghese, Dhanapal K & Vijayan A K
S5 P56	Studies on microbial contamination in stored nutmeg and mace	Amritha K R, Vijayan A K, Saju K A, Gopakumar K & Rema Shree A B
S5 P57	Study on Seasonal variation of growth, Flowering and Fruiting in Nutmeg (Myristica fragrance Houtt.)	Shigvan K Y, Khandekar R G, Shedage M S, Mali P C & Khedkar S P
S5 P58	Bioefficacy of biopesticide and fungicide on percent disease index of coriander powdery mildew (Erysiphe polygoni)	Bhavana Yadav, Reena Nair, Saxena A K & Nazneen Husain
S5 P59	Management of coriander powdery mildew using new generation molecules	Kumawat G L, Sharma R N, Shivran A C, Gothwal D K & Dharendra Singh
S5 P60	Organic production of leafy coriander in homesteads	Sheeba Rebecca Isaac, Bindu Podikunju & Anjaly V
S5 P61	Screening of coriander genotypes against stem gall disease to identify early cultivars with disease resistance or tolerance: A case study done in Hadoti region of Rajasthan	Preeti Verma, Meena C B, Yadav M L, Solanki R K & Kakani R K
S5 P62	Delineation of cumin production zone beyond boundaries based on climate analogues and soil suitability	Swetha Sudhakaran V, Faras Bin Muhammed, Krishnamurthy K S, Kandiannan K, Alagupalamuthirsolai M & Jayarajan K
S5 P63	Effect of sulphur and bio-regulators on yield and quality of cumin	Mehriya M L, Neelam Geat, Sarita & Hitesh borana
S5 P64	Organic nutrients and wilt disease management in cumin Cuminum cyminum	Shivran A C, Kumawat G L, Gothwal D K & Dharendra Singh
S5 P65	Screening of effective Zn solubilizing microorganisms from Cumin (Cuminum cyminum) rhizosphere	Brijesh Kumar Mishra & Dhanni Devi

No.	Title	Authors
S5 P66	Pest scenario on fennel (<i>Foeniculum vulgare</i> Mill.) under organic production system in semi-arid region of Rajasthan	Meena N K, Lal G, Meena R D & Choudhary M
S5 P67	Chemo-profiling of fenugreek genotypes	Sanjeev Agrawal & Neetu Pathak
S5 P68	Studies on genetic variability, character association for yield and its attributes in fenugreek (<i>Trigonella foenum-graecum</i> L.)	Meena R S, Suresh Kumar Bagra & Prerena Sharma
S5 P69	Studies on the effect of inorganic fertilizers and bio-inoculant (rhizobium, PSB and KSB) on symbiotic properties and yield of fenugreek	Nazneen Husain, Reena Nair, Sahu R K & Bhavna Yadav
S5 P70	Physiological evaluation of ajwain crop in climate change scenario of Maharashtra	Pawar G S & Chibde B R
S5 P71	Seed spices to combat soil salinity: A thematic approach	Ravi Y, Saxena S N, Verma A K & Lal G
S5 P72	Assessment of kharif onion varieties in Dewas district of Madhya Pradesh	Nishith Gupta, Dixit A K & Bhargav K S
S5 P73	Evaluation of different genotypes of garlic (<i>Allium sativum</i> L.) under Malwa Plateau of Madhya Pradesh	Meena K C, Ghoshi S K, Naruka I S, Haldar A, Soni N & Alam Khan K
S5 P74	Evaluation of curry leaf genotypes for genetic variability and quality traits	Vithya K & Shoba N
S5 P75	Evaluation of curry leaf <i>Murraya koenigii</i> L. genotypes for yield and quality	Anila Peter & Krishnakumary K
S5 P76	Genetic variability, correlation and path analysis of tamarind (<i>Tamarindus indica</i> L.)	Rajamanickam C
S5 P77	Performance of elite tamarind genotypes (<i>Tamarindus indica</i> L.) for yield and qualities	Siddappa R, Prashanth M, Prakash B G & Manjunath Hubballi
S5 P78	Performance of tamarind (<i>Tamarindus indica</i> L.) collection for pod yield and quality	Jansirani P, Chitra R & Prabhu S
S5 P79	Identification of soil less substrate and host for farm level mass multiplication of arbuscular mycorrhizae	Sarathambal C, Jeevalatha A, Srinivasan V, Dinesh R & Shahana AP

No.	Title	Authors
S5 P80	Insecticidal activities of essential oils and their combinations from spice crops against stored grain insect pests in stored wheat and chickpea	Ranjeet Kumar & Pandey P S
S5 P81	Management of isabgul aphid, Aphis gossypii Glover through different insecticides under north Gujarat conditions	Prajapati B G, Gondaliya S B & Amin A U
S5 P82	On-site DUS testing of farmer's varieties in spices through PPV & FR Act 2001	Hemesh K, Saji K V, Rema J, Prasath D, Shivakumar M S & Akshitha H J
S5 P83	Use of sulfur nanoparticles as a green pesticide on storage pest Sitotroga cerealella	Thejanuo Rhetso & Sivaram V

Abstracts



**H. S. MEHTA MEMORIAL
AWARD
PRESENTATION**

HS 1

Evaluating the effect of a novel *Curcuma amada* bioactive, 2,4,6-trihydroxy-3,5-diprenyldihydrochalcone and avocatin B On mitochondrial metabolism in acute myeloid leukemia

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Mango ginger (*Curcuma amada*) roots historically have been used in traditional medicine, but isolated bioactive compounds have seldom been studied. Earlier, an antimicrobial compound, difurocumenonol was identified. More recently we identified 2,4,6-trihydroxy-3,5-diprenyldihydrochalcone (hereafter referred as M1) from *C. amada*. M1 has powerful antimicrobial properties. We tested the effects of M1 on Acute Myeloid Leukemia (AML). AML is an aggressive blood cancer with limited chemotherapy options and negative patient outcomes. Nutraceuticals such as avocatin B, a fatty-acid oxidation (FAO) inhibitor, are promising options for treatment. This study investigated the antileukemic properties of M1 and its effects on mitochondrial metabolism. M1 reduced the viability of multiple leukemic cell lines but demonstrated toxicity in normal cells. A window of synergy at low concentrations was identified with M1 and avocatin B, which was selective to leukemic cells. The M1 and avocatin B combination inhibited FAO by 60%, a process essential to the synergy. M1 and the combination inhibited complex I of the electron transport chain; M1 also reduces glycolysis. These results demonstrate M1's potential as a novel chemotherapeutic for AML.

HS 2

A re-look into the fungicide sensitivity of *Pythium deliense* associated with yellowing of black pepper (*Piper nigrum* L.)

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An investigation on the etiology of yellowing and wilting of black pepper plants during the advent of post monsoon season revealed the predominant association of *Pythium deliense*. Before being known the etiology of the phenomenon, several management strategies integrating fungicides, were in practice. But still yellowing is prevalent in many black pepper gardens. So there arises a need for relooking into the sensitivity of fungicides towards the pathogen. Apart from this, *P. deliense* being an oomycete pathogen, it is also pertinent to screen new generation fungicide molecules. Hence initial *in vitro* screening was done with eleven fungicides including commonly used Copper Oxychloride (2500 ppm) and Metalaxyl-mancozeb (1250 ppm). The new molecules tested were Famoxadone + Cymoxanil (1000 ppm), Cymoxanil + Mancozeb (2000 ppm), RIL (400 ppm), Propiconazole (2000 ppm), Propineb (1000 ppm), Chlorothalonil (1000 ppm), Kresoxym methyl (700 ppm), Iprovalicarb + Propineb (1000 ppm) and Fenamidone-mancozeb(500 ppm). The pathogen

was found sensitive only to Metalaxyl-mancozeb (1250 ppm), Propiconazole (2000 ppm), Fenamidone-mancozeb (500 ppm) and RIL (400 ppm). However the pathogen showed resurgence of growth on prolonged incubation in these concentrations of fungicides. Moreover it is also found that Copper Oxychloride is not sensitive to *P. deliense*. So screening was repeated with higher concentrations of Metalaxyl- mancozeb (1250 ppm-2000 ppm), Propiconazole (2000 ppm- 3000 ppm) and Fenamidone- mancozeb (500 ppm-1000 ppm). The results showed that Metalaxyl- mancozeb is completely inhibitory at 1750 ppm while Propiconazole and Fenamidone- mancozeb exhibited 100% inhibition at 3000 ppm and 1000 ppm respectively. Mycelial degradation was also noticed in these higher concentrations of all the tested fungicides indicating no resurgence of growth in these concentrations. LD₉₀ values were found to be, 1496.86 ppm, 604.99 ppm and 2497 ppm respectively for Metalaxyl-mancozeb, Fenamidone-mancozeb and Propiconazole. These fungicides were further tested *in planta* under green house conditions by challenge inoculation where treatment with Propiconazole showed visible symptoms as wilting followed by root rot (15%). Even though there were no visible symptoms of yellowing or wilting root rot was found @ 11.1% in case of Metalaxyl-mancozeb and 16.7% in case of Fenamidone-mancozeb suggesting the need for higher concentrations of all the three fungicides for the management of *P. deliense* induced yellowing in black pepper.

HS 3

Designing a supply chain network to monitor the quality of black pepper in International trade

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Spices, characterised by their unique flavour and aroma have always been a highly valuable product that has allured international traders towards India since ancient times. Black pepper (*Piper nigrum*), considered as the 'king of spices' has always ruled the spices trade by being the most demanded with a global market value of US\$ 3.7 billion (2017) as estimated by the Trade Promotion Council, India (TPC). Despite being the largest exporter of spices in the world, India has failed to hold its stand in the black pepper market as its export has plummeted since 2011 to an ever low value of US\$ 51 million in 2018 (ITC). This raises a critical need to recover the black pepper trade by improving the overall production and quality according to the international trade regulations. The decline in the export mainly owes to the reduced production of black pepper because of plant diseases like foot rot, improper post-harvest handling and export rejections due to non-adherence to the stringent standards of international agencies. Inefficient management throughout the supply chain and lack of awareness about maintaining good quality and high standards at all levels has led to the weakening of its international trade from India. The objective of the present study is to improve and optimise the existing supply chain of black pepper in India, to enhance the efficiency of the network and quality of the product rendering it competent in the international market. We have extensively studied the current supply chain to identify the drivers and shortcomings in the network and also analysed the fundamental requirements of importers and consumers in the world market. After comparing both the

data we have devised a supply chain network with improved transparency and laid down the critical points in the network along with the processing techniques and advancements in trace ability that can further augment the significance of Indian black pepper in the world market.

HS 4

Export performance and competitiveness: The case of Indian black pepper

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India, with an area of 1.35 lakh ha and production of 64,000 tonnes in 2017-18, is one among the leading producers of black pepper in the world. India contributed a share of 4.8 per cent to the total world export of black pepper and 7.4 per cent to the total world import of black pepper in 2018. India is one of the major exporters of black pepper to the world after Vietnam, Indonesia and Brazil, whereas US, Germany, India and Vietnam are the major importers of black pepper. The country has lost its position as the major producer and exporter of black pepper to Vietnam, since 1999. Because of the increasing domestic consumption of black pepper and increasing competition from other producers, especially, Vietnam, only a limited amount of black pepper is exported from the country. The present paper analyses the export performance of black pepper from India in terms of export growth rate and instability, Revealed Comparative Advantage (RCA), sources of growth and variability in export value and the geographic concentration of export. During the pre-WTO period, the growth rates in terms of export value, quantity and unit value were found to be higher and positive, while the instability in export was comparatively low. Post-WTO period recorded negative growth rate and high instability in export of black pepper. Lower growth rate and higher instability observed during post-WTO could be the result of increased domestic demand and stiff competition in international market especially from Vietnam. As per the IPC estimates about 50 to 60 per cent of Indian production is consumed in the country itself. Vietnam was not a competitor in international market till 1999, as it is evident from the RCA value of black pepper. All the countries had RCA index of nearly seven during 1990. RCA index of Vietnam has increased over the years and Vietnam recorded the highest RCA index of 71.3 in 2018, whereas for India it was 2.1. Change in mean export unit value was found to be the major source of growth in value of export rather than the change in mean export quantity during both pre- and post-WTO periods, while the change in variability of export unit value contributed more to the change in variance of export value. After liberalization, the diversification in terms of number of countries to which black pepper is exported from India has increased and the stable market for Indian black pepper exports were USA, UK and Canada. Increasing domestic demand, stiff competition from other producing countries, low production and productivity, price volatility and Non-Tariff Barriers were the major issues that need to be addressed to strengthen the export of black pepper from India.

HS 5

Genotyping of black pepper using a novel resistance related gene polymorphism

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Plants possess a large number of R genes that play key roles in plant defense against pathogens. During the dynamic interaction between plants and pathogens, plants counter the evolution of pathogen avirulence genes with the evolution of new resistance genes. The polymorphism in the R gene among black pepper genotypes would serve as identification markers for them. With this hypothesis, we explored the potential of differentially regulated LRR type disease resistance protein in black pepper variety IISR-Shakthi identified upon *Phytophthora* interaction from our earlier proteomics study towards differentiating the genotypes. The primers derived from this protein coding gene showed amplification in the 22 tested genotypes. The microchip gel electrophoresis system analysis of the PCR products discriminated each genotype from the other. The PCR length polymorphism and the differential duplication pattern were the major discriminating factors for differentiating the genotypes. The sequencing & BLAST analysis proved their identity as disease resistance gene. Analysis with the whole genome sequence of black pepper showed the presence of the amplified region in particular chromosome. With the lack of a robust marker for genotyping in black pepper, this functional gene can be used to genotype the breeding sources in the pre-breeding & also in MAS programs towards black pepper improvement.

HS 6

Influence of temperature and relative humidity on the disease incidence in virus infected black pepper

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Piper yellow mottle virus (PYMoV) cause yellow mottle disease in black pepper which is a serious emerging disease in all black pepper growing countries including India. Disease incidence and severity are high when plants are subjected to abiotic stress like temperature. In the present study influence of temperature and relative humidity (RH) on symptom expression, disease incidence and biochemical parameters of PYMoV infected black pepper were investigated. Asymptomatic PYMoV-infected plants confirmed by RT-PCR assay of 19 popular black pepper varieties viz., Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Panniyur-6, Panniyur-7, Panniyur-8, Panniyur-9, Vijay, PLD-2, Arka Coorg Excel, IISR-Malabar Excel, Pournami, IISR-Shakthi, Subhakara, Sreekara, IISR-Girimunda and Panchami, were maintained in polyhouse during 2019-20. Temperature and RH were recorded in the polyhouse at 8:30 am and 2:30 pm daily. Symptom expression and disease incidence were recorded in all 19 varieties of black pepper on weekly basis starting from January 2019 to January 2020. Another set of plants were maintained in the greenhouse where temperature and RH were maintained at 26 °C and 80 %. Analysis of the results showed that disease incidence was significantly correlated with temperature and RH at

2:30 pm. The plants showed gradual increase in average per cent disease incidence from 9 % during 11th Standard meteorological week (SMW) (13th March, 2019) to 39 % during 21st SMW (22nd May, 2019) when temperature and RH ranged between 30 °C to 40 °C and 70 to 92 %, respectively. During 22nd to 53rd SMW (28th May, 2019 to 1st January, 2020) there was a fall in the average disease incidence from 39 to 1%, when average temperature ranged between 30 °C to 36 °C and RH ranged between 70 to 86 %. Varieties *viz.*, Arka Coorg Excel, Panniyur-2 and Panniyur-6 recorded high average per cent disease incidence of 56%, 25% and 27% respectively and IISR-Malabar Excel and Pournami recorded the low average disease incidence of 2% and 2.5% respectively. SYBR Green based real-time reverse-transcriptase PCR assay conducted at bimonthly interval revealed increased virus titre in plants in the month of December, 2019 indicating no correlation between symptom expression and virus titre. Varieties were categorized as high, medium and low based on disease incidence. Among these, one variety each representing high, medium and low incidence was selected from polyhouse and greenhouse for biochemical assays. Increase in total proteins, carbohydrates, phenols, lipid peroxidase and superoxidase dismutase activities were observed in plants kept at polyhouse compared to the plant from greenhouse. In contrast, higher amount of total chlorophyll was observed in plants from greenhouse compared with plants from polyhouse. Overall results indicate clearly that the stress due to high temperature and relative humidity has direct influence on virus titre in the host, symptom expression and biochemical parameters.

HS 7

Direct 1H-NMR method for simultaneous determination of total curcuminoids and individual curcuminoids

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Turmeric is one of the major spices that have a very long history, along with its medicinal properties to cure number of health ailments. This is mainly due to the occurrence of a yellow pigment called curcumin present in the turmeric. Curcumin has been extensively studied for numerous pharmacological properties. Curcumin extracted from rhizome contains complex mixture (Curcuminoids) of three different forms. Each curcuminoids has distinguished medical application. Percentage of these curcuminoids form varies based on the turmeric varieties and their geographical origin. Generally, AOAC specifies UV method for the quantification of curcuminoids. The analysis follows complex sample preparation protocols but it fails to quantify the individual curcuminoids. These can be circumvented by a well sophisticated analytical technique like UPLC, HPLC, and LC-MS method. Unfortunately, the major drawbacks of chromatographic assay or potency determination are the procurement of the reference standard. In a recent development of NMR studies, qNMR has emerged as a versatile tool for the exact quantification of the desired compounds using a specific internal standard (IS) in a short time and with minimal sample preparation with high accuracy and robustness. In the present studies, we are utilizing simple and fast 1H-NMR based protocol for direct quantification of curcuminoids. Furthermore, our protocol is also useful for quantification of individual curcuminoids present. The analysis shows that the robustness and specificity of proposed qNMR test method for quantification of total curcuminoids those are matching with a selected linearity range in

comparison with AOAC UV-Visible spectroscopic estimation. The accuracy of the methods was calculated by the recovery study and the proposed method is found to be precise and linear. The significance of these studies relies on improving the methodology concerned with the resource available and minimal use of solvent and reagents. The simultaneous determination of the total curcuminoids and individual curcuminoids content is helpful to understand the geographical origin and quality of the turmeric.

HS 8

On the fly NMR for quantification of curcuminoids present in the turmeric

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The pharmacological importance of turmeric comes from its phytochemical constituent mainly Curcuminoids comprising Curcumin (C), Demethoxycurcumin (DMC), and Bisdemethoxycurcumin (BDMC). These three curcuminoids impart distinctive yellow color to turmeric. Each curcuminoid have similar or little higher bioactive potential and the mixture will be more potent than individual curcuminoids. Curcuminoids can be used as potential therapeutic implications for various neurodegenerative diseases, where major neuroprotective potency is shown by DMC followed by BDMC and curcumin. Whereas the anticancer property of BDMC and the antioxidant activity of curcumin is relatively higher as compared to DMC. The percentage of curcuminoids varies depending on various factors like species, geographical location, climate etc. So quantification and knowledge of presence of these curcuminoids is very important due to its promising biological activities. Several methods including HPLC and LC/MS have been described for the determination of different curcumin content in turmeric. These techniques are time consuming compared to NMR method, which provides simultaneous detection of both identity and quantity. Till now the ^1H NMR method reported only the presence of curcumin, and its pure form followed by its structural studies. In the present studies we are utilizing on the fly NMR for determination of percentage of curcuminoids. We have shown that our protocol can be directly used to get light on the presence of different curcuminoids from intact samples. The optimized protocol has further explored on the turmeric samples from different geographical locations in India *viz.*, Andhra Pradesh, Assam, Maharashtra, and Mysore for the individual curcuminoid content. The results showed that curcumin content was more in all varieties followed by DMC and BDMC, except in Andhra Pradesh turmeric variety where BDMC is more compared to DMC. The result was validated with widely used HPLC methods. The simple protocol and on the fly analysis of individual curcuminoids from different origins of turmeric will help in identifying the suitable variety for the required biological activity of interest for further studies. For example, we can use Andhra Pradesh turmeric variety for anti-cancer activity since it has more BDMC content compared to other varieties.

HS 9

R2R3 MYBs exhibits antagonistic effects in regulation of curcumin biosynthesis in turmeric (*Curcuma longa* L.)

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Plant secondary metabolism is regulated through an interplay mechanism of R2R3-MYB activators and repressors on the common target genes of the biosynthetic pathway. Identification of the correct isoform of genes and transcription factors regulating the pathway thus assumes significance since the function of one isoform may be the opposite of the other. Comparative analysis of transcript profiling data of *Curcuma longa* identified two isoforms of MYBs having contrasting characters with respect to curcumin. One MYB was upregulated whereas the other one was down regulated under high curcumin conditions. This study aims to analyse the regulatory role of two MYB transcription factors depicting antagonistic action with respect to curcumin as evident from the docking studies as well as real time expression analysis involving different tissues of turmeric. We also compared the binding affinities of two MYBs with the promoters of a novel putative gene involved in curcumin biosynthesis. The MYBs were amplified from both genomic DNA as well as from cDNA and the intronic regions were deduced from a comparison between cDNA and genomic sequences. The putative activator MYB is 1064 bp in length and contains an ORF of 717 bases and the repressor is 1044 bp in length and ORF is 627 bases. The intron-exon organization of the two R2R3-MYB genes of *Curcuma longa* was evaluated and both MYBs exhibited the highly conserved organization of three exons and two introns. By comparing the gene structures of *Curcuma longa* MYBs and other plant R2R3-MYB type genes, we found that other plant MYBs also have the same number of exons and introns but were divergent in gene sizes, mainly due to the variable intron sizes. Putative activator MYB protein is composed of 238 amino acids with molecular mass of 26.14 kDa and PI of 6.96. Putative repressor MYB had 207 amino acids with molecular mass 23.04 kDa and PI of 9.04. Further, both the MYBs was predicted to have two conserved MYB domains, which is a typical feature of R2R3-MYB subfamily. It may be assumed that these MYBs with functional redundancy and antagonistic effects may be that which confer the plants to switch their metabolism in response to environmental cues resulting in regulation of the curcumin pathway.

HS 10

Chitosan - A biostimulant for transplanted ginger

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Chitosan is a widely preferred biopolymer due to its biocompatibility, biodegradability and non-toxic properties. It is a cationic polysaccharide obtained by the alkaline deacetylation of chitin, produced from waste resources such as marine crustacean shells. It is mainly exploited for enhancing crop production due to its biostimulant effects such as improving

germination, plant growth, yield *etc.* A field experiment was undertaken at Kerala Agricultural University, Thrissur, to know the biostimulant effect of chitosan on growth and yield of transplanted ginger. The experiment was laid out in completely randomised design. The ginger transplants were planted in polybags in three replications. Chitosan at different concentrations *viz.*, 0 (control), 1, 3, 5 and 7 g L⁻¹ were given as a foliar spray at monthly interval. The plant height and number of tillers were the highest in plants treated with chitosan 5 g L⁻¹ (68.6 cm and 13.26 respectively). But the leaf area was highest in plants treated with chitosan 7 g L⁻¹ (35.64 cm²). Plants sprayed with chitosan 5 g L⁻¹ was found superior in terms of fresh weight of rhizome (353.42 g plant⁻¹). Number of fingers were highest in rhizomes of plants treated with chitosan 3g/L followed by chitosan 5 g L⁻¹. Foliar application of chitosan at a concentration of 5 g L⁻¹ is effective in enhancing yield in ginger transplants. Hence, chitosan has a promising future in development of sustainable agricultural practises and ensuring food safety.

HS 11

Enzyme assisted extraction of essential oil from *Zingiber zerumbet* rhizome

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Zingiber zerumbet an aromatic tuberose plant, displays various pharmacological activities due to the presence of zerumbone, a sesquiterpene molecule. It is mainly present in the volatile oil, which is extracted by hydrodistillation methods. The present work describes the extraction of essential oil and oleoresin from *Z. zerumbet*. Over the years, numerous procedures have been proposed for the extraction of bioactive compounds from the rhizome of *Z. zerumbet* rhizome such as steam distillation, solvent extraction, hydro-distillation, fractional distillation, supercritical CO₂ extraction, continuous subcritical water extraction, sub supercritical fluid extraction, microwave-assisted extraction, ultrasound-assisted extraction, soxhlet extraction. Among these, the hydro-distillation method affords an essential oil yield of 3.7%. Various enzymes are generally used to enhance the extraction of the desired components by a way of breaking the structural integrity of plant parts. Hence, the present investigation relates to the feasibility of extraction of essential oil and oleoresin from *Z. zerumbet* rhizomes by enzyme assisted hydrodistillation and enzyme assisted solvent extraction. Pre-treatment of *Z. zerumbet* rhizome powder with enzymes (α -amylase, bio-protease, cellulase, enzymes from herbal extract, hemicellulose, pectinase, and viscozyme) before hydro distillation and various solvent extraction (ethanol, methanol, isopropanol, acetone, dichloromethane, ethyl acetate, and chloroform) were optimized under different treatment conditions of varying temperature (30 °C, 40 °C and 50 °C) with incubation time (60 min, 90 min, and 120 min) at different concentration of enzyme (1% to 5%). It was found that in the enzyme assisted hydrodistillation method there is a higher percentage recovery of the volatile oil of *Z. zerumbet* than the control. The recovery of oil varied between 3.28 to 4% in comparison to control samples where enzyme treatment was absent (3.2%). The highest recovery (4.0%) was found in pectinase, hemicellulose, viscozyme and amylase enzyme with the optimized condition of incubation for 1 h at 30 °C. Under similar conditions, the yield of oil in the case of cellulose, herbal extract, and bio protease treated sample was 3.8, 3.6, and 3.28 % respectively. In general, the oil yield

was improved by 25% in the case of pectinase, hemicellulose, viscozyme, and amylase and 18.75, 12.5 and 2.5% increase in the case of cellulose, herbal extract and bio protease enzyme treatment respectively. GC profile all the extracts were carried out. In the case of oleoresin extraction, enzyme treatment was carried out before solvent maceration. It was found that there is an increase in percentage recovery of oleoresin in ethanol, methanol, isopropanol, acetone in comparison with untreated samples. The range is 6 to 8.8%, 5.3 to 7%, 4.3 to 6.2%, 4.1 to 5.7% respectively. The maximum yield gain accounting to 47% was with ethanol.

HS 12

Comparative transcriptome profiling of tolerant vs. susceptible large cardamom (*Amomum subulatum* Roxb.) cultivars in response to the chirke virus infection

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Large cardamom (*Amomum subulatum* Roxb.), is an ancient highly valued spice crop belonging to the family Zingiberaceae and is cultivated in the Himalayan subtropics including Sikkim state, Darjeeling, and parts of North Eastern states of India. Since long, severe economic losses have been faced by large cardamom farmers due to Chirke disease caused by Large Cardamom Chirke Virus (LCCV). To reveal the molecular mechanisms of virus infections underpinning the large cardamom, high throughput RNA sequencing and de novo assembly of chirke virus infected and tolerant leaf transcriptomes was undertaken in the present study. RNA-seq generated 38630484*2=77260968 (7.72 GB) and 36119854*2=72239708 (7.22 GB) raw reads and of sequence data for large cardamom control and diseased samples respectively. The raw data were submitted to NCBI SRA database under the accession numbers SRX2529372 and SRX2529373. To elucidate the underlying dys regulated biological processes, *in silico* pathways and mechanistic analysis was conducted. This report highlights some of the results of this integrated *in silico* analysis and introduces a proposed workflow for the analysis and interpretation of RNA-Seq data analysis. This Functional Genomics Resource for large cardamom will aid future breeding programmes since no data is presently available for large cardamom.

HS 13

Effect of micro-nutrients on *in vitro* androgenesis for production of double haploids (DHs) in chilli (*Capsicum annum* L.) cv. Byadgi dabbi

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The chilli cv. Byadgi Dabbi is a famous and widely grown commercial dry chilli variety in Karnataka, India. It is characterised by deep red, highly wrinkled fruits with characteristic flavour, aroma, low pungency, high color level and oleoresin that makes it the most preferred

variety for export. It has been accorded with Geographical Indication. Farmers, traders and consumers alike stated that yield and more specifically quality feature of Byadgi chilli is deteriorating year after year because of introgression of undesirable genes from other chilli varieties/hybrids. Hence, for restoring the past glory of this variety, there is an urgent need for genetic purification and improving the yield potential of this variety without sacrificing the good quality which is a challenging task for the breeders. Biotechnological tools such as tissue culture techniques and specifically anther culture may be applied successfully for plant breeding and genetic improvement to generate complete homozygous lines in a shorter time in comparison with the classic breeding methods. The most widely used media were Sibi and Dumas media. For further improvement, the original Dumas media has been modified by varying the concentrations of micro-nutrients. In the present study our main objective was to know the effect of micro-nutrients *viz.*, $\text{MnSO}_4 \cdot \text{H}_2\text{O}$, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, H_3BO_3 , KI, $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, and $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ on *in vitro* production of DHs in Byadgi Dabbi through anther culture. During the study, the anthers isolated from flower buds of cv. Byadgi Dabbi grown in a plant growth chamber were cultured on solid induction medium. Three basal induction media *viz.*, Sibi, Dumas and Modified Dumas media were tested in eight replications. Method/steps shown here in the flow chart were followed in all the media and all the replications. Selection of floral buds → Detection of the pollen development stage → Surface sterilisation → Anther dissection → Anther placement on the medium → Embryo development → Haploid plantlets → Confirmation of ploidy → Chromosome doubling → Doubled haploids (DHs) → Hardening. The data were subjected to Analysis of Variance (ANOVA). The embryo induction was observed in all three media. The type and color of the embryos induced were solitary and white in all three media. The growth rate was medium in all media. The highest frequency of embryo induction was observed in modified Dumas media (6.25 %) followed by Dumas media (3.38 %) and Sibi Media (2.23 %). It was observed that modified Dumas Media was superior over the original Dumas Media (45.92 %) and Sibi Media (64.32 %). The most promising Modified Dumas Media was supplemented with $20.13 \text{ mg l}^{-1} \text{ MnSO}_4 \cdot \text{H}_2\text{O}$, $3.22 \text{ mg l}^{-1} \text{ ZnSO}_4 \cdot 7\text{H}_2\text{O}$, $1.55 \text{ mg l}^{-1} \text{ H}_3\text{BO}_3$, $0.33 \text{ mg l}^{-1} \text{ KI}$, $0.13 \text{ mg l}^{-1} \text{ Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, $0.01 \text{ mg l}^{-1} \text{ CuSO}_4 \cdot 5\text{H}_2\text{O}$, and $0.01 \text{ mg l}^{-1} \text{ CoCl}_2 \cdot 6\text{H}_2\text{O}$ and 0.20 mg l^{-1} 2,4-D. Modified Dumas Media (DBM) was found to be most promising in inducing *in vitro* androgenesis for production of double haploids (DHs) in chilli (*Capsicum annuum* L.) cv. Byadgi Dabbi.

HS 14

DUS-Tool exploitation for evaluation of tamarind germplasms of coastal midland region of Kerala

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Seventeen bearing tamarind trees from the Kerala Agricultural University, Thrissur main campus were selected for the study after preliminary survey and GPS coordinates were recorded for generating passport data. These accessions were observed for DUS characters *viz.*, foliage, panicle, fruit and biochemical parameters. Ten out of 17 selected accessions were regular yielders. Upright (47.06 %), semi-spreading (41.17 %) and spreading (11.77 %) types of growth habits were observed. Sizable variability was noticed in foliage characters. The average panicle length ranged from 7.8 cm (KTI-6) to 32 cm (KTI-17). Wide range of

variability was expressed in pod characters and biochemical composition. The average pod length was highest in Acc. KTI-16 (19.22 cm). Acc. KTI-10 recorded highest average fruit weight (26.60 g) followed by Acc. KTI-16 (23.64 g). The number of fruits per unit area of the canopy ranged from 2.83 to 9.83 among the selected accessions. Highest pulp: seed ratio was recorded in Accession KTI-7 (1.9) while the lowest was recorded by Accession KTI-15 (0.87). High variability was also noticed in biochemical composition of pulp like titratable acidity (7.79 to 21.94 %), TSS (55 to 70°Brix) and Vitamin-C (11.17 mg to 18.91 mg per 100 g). Accession KTI-12 recorded highest tartaric acid, Acc. KTI-3 recorded highest TSS and Acc. KTI-17 recorded highest Vitamin-C. Principal component analysis of yield attributing characters like number of fruits per unit area, pod length, pod girth, pod weight, pulp weight, pulp content, seed weight and number of seed per pod grouped accessions into nine clusters. Accession KTI-13 and accession KTI-17 which were members of Cluster VII were marked as outstanding in terms of higher fruit yield per unit area of canopy and these accessions can be utilized for further breeding programmes.

HS 15

Exploitation of functional spice malabar tamarind (*Garcinia gummigutta*) for diversified value added product

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Malabar tamarind (*Garcinia gummigutta* (L.)) is one of the functional spice, which belongs to the family Guttiferae. Fruit rind is commonly used for the culinary purpose as food preservative, tendering agent, flavouring agent or food-bulking agent in the preparation of some vegetarian dishes like chutneys and to enhance the taste, texture of foods and to remove the unpleasant smell of meat. Since the raw Malabar tamarind fruit is very sour to consume, dried rind and concentrated pulp is sold as an acidulant in the market. It is reportedly gaining lot of media attention in recent days due to its Anti-obesity component called Hydroxy citric acid (HCA). HCA is being proved to reduce the biosynthesis of fatty acid and cholesterol. This in turn indicates satiety, thus helps to suppress the appetite for longer time. In spite of several functional properties and commercial importance, the crop remains neglected and hence there is a need to concentrate on diversification and popularization of such underutilized fruits through the development of value added products. To exploit the health promoting properties of the fruit, it has been studied for its physico-chemical properties, standardization and development of value added products from both fresh and dry rind namely Jujubes (MTJB), Jaljeera (MTJJ), Khatta-meeta Candy (MTC), Soup (MTSP), Sauce (MTSA) and Chutney Powder (MTCP) at different proportions of Malabar tamarind. The developed products were subjected for organoleptic evaluation using nine point hedonic scale on all the products and the results indicate that Candy (MTC-65%) and Chutney powder (MTCP-1.5%) were scored high for overall acceptability among all other products. Macro and micro nutrient contents were improved upon Malabar tamarind incorporation. Best accepted value added products were stored for three months duration in high density polyethylene pouch and glass jar under both ambient and refrigerated conditions to study the shelf life of the products. There was a

significant increase in the moisture, titratable acidity in candy and free fatty acid value in chutney powder under ambient condition irrespective of the packaging material, as storage period prolongs. However, the sensory scores for both the best accepted products were in acceptable level throughout the storage period. Microbial load was found to be in permissible limit under refrigerated condition in both the products. From the results, the best sensorily accepted nutri-dense products can be used to promote for regular consumption for its superior functional properties to maintain optimum health status of human beings and also to reduce the post harvest losses of the underutilized fruit.

HS 16

Determination of sudan dyes in saffron of Indian origin using HPLC technique

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Saffron is an important commercial crop of India, particularly grown in area of Jammu and Kashmir. Saffron has tremendous medicinal properties with several health promoting compounds and therefore it is used in many of food items, ayurvedic medicine and modern pharmaceuticals. Since saffron is the costliest spice and its production is limited due to requirement of specific agro-climatic conditions, therefore various fraudulent practices are employed by the traders to gain economic benefits. Mainly, the fraudulent practices include adding of safflower, marigold, fibers of corn etc. to increase the weight and chemical dyes such as Allura red, Tartrazine, Quinoline yellow, Sudan dyes etc. are added to the saffron to produce the intense color so as to misguide the consumer about quality of saffron. Among various dyes, Sudan dyes are the most harmful, known to have carcinogenic effect. Although various efforts are being made by research community to detect different adulterants in saffron using variety of methods but not much is documented for harmful Sudan dyes. In order to ensure the food safety associated with consumption of saffron, a research attempt is being made to detect adulteration of Sudan dyes in saffron using HPLC technique. Saffron procured from Jammu and Kashmir is analyzed first for study of physico-chemical parameters (moisture content, ash content etc.) and important chemical constituents including crocin, picocrocin, safranal were measured using UV-vis spectrophotometer and HPLC (High Performance Liquid Chromatography). Peaks of main compositional constituents were observed at wavelengths 257 nm, 330 nm and 440 nm. Then saffron solution spiked with sudan dyes including Sudan Orange G, Sudan Red G, Sudan II, Sudan IV were injected into HPLC and corresponding peaks were obtained at wavelength 510 nm on RT 3.63, 4.03, 7.68, 23.51 minute respectively for each dye (concentration 50 ppm in saffron solution). Present study reports that HPLC may be used effectively to detect the presence of harmful Sudan dyes in saffron thus enabling to safeguard the consumer health and to meet the norms of quality at international level.

HS 17

Effect of different storage conditions and packaging material on shelf life of coriander leaves (*Coriandrum sativum* L.)

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Coriander (*Coriandrum sativum* L.) leaves are one of the important ingredients of Indian cuisine. It is a perishable herbal spice due to its delicate leaves, improper handling during marketing, lack of suitable storage conditions and packaging materials. The present study was carried out in the Dept. of Plantation Crops and Spices of College of Horticulture, Kerala Agricultural University to evaluate the effect of different storage conditions and packaging material on the shelf life of coriander leaves. Fresh coriander leaves of 100 ± 2 g weight, collected from the field grown crop was packed in different types of packing material *viz.*, LDPE 200, 350 and 440, tissue paper and brown paper cover. Packed samples were kept in three different storage conditions *viz.*, ambient (27 °C), refrigeration (4 °C) and cold storage (13 °C). Packaging material and storage conditions had significant effect on shelf life and quality of coriander leaves. Maximum shelf life was obtained in refrigeration (10 days) followed by the sample kept in cold storage (8 days). The minimum shelf life was observed in ambient condition (4 days) after which the sample rotted. Significantly higher percentage of physiological loss in weight was observed in the sample packed in tissue paper and brown paper covers. The minimum percentage of physiological loss in weight was observed in sample packed in LDPE 350 which was on par with LDPE 200 and 440 in all the storage conditions. The physiological loss in weight gradually increased during storage. There was no significant difference in the physiological loss in weight in sample packed in LDPE 350 and 440 after 10 days of packing in refrigeration. The appearance and quality of the leaves was good and acceptable and rotting percentage was minimum in the sample packed with LDPE 350 in all the storage conditions. The coriander leaves under refrigeration packed with LDPE 350 remained fresh, greenish, and saleable and the rotting percentage was minimum after 10 days of packing. In all the storage conditions, LDPE 350 was found to be the suitable packaging material followed by LDPE 440. Tissue paper wrapping and brown paper cover was found to be the poor packaging material as these samples recorded higher physiological loss in weight within 2 days after packing in all the storage conditions. Between LDPE 440 and 350, the latter was found to be cost effective packing material.

HS 18

Flavours for better health- “Ancient goodness spiced up in a new wrap”

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Flavors rejuvenate our lives. Flavours have penetrated different worlds, from kitchen to beauty packs, herbal tea sip to a leisure high end aromatherapy, simple namkins to ice creams and the list goes on. Natural flavours demand is increasing day by day as the world is turning back to nature for all its benefits. This demand drives one to look for

different combination of flavours so new products can be developed that is appealing and curing. The great concern today is the health issues the present generation is facing. The best way to combat these issues is to build the immunity of the children. An attempt was made to fortify the most liked foods of children with some high packed antimicrobial, anti-oxidant and digestive compounds from some spices and medicinal plants. Before fortifying the foods the combined effect of the extracts of black cumin, fennel, Tulasi, star aniseed and Cinnamon were tested against *E. coli*, *Streptomyces* and some fungi by well diffusion method. NA media for bacteria and PDA for the fungi were used for well diffusion method. The Zone of inhibition was measured. The combination is most effective against *E. coli*. The extract also showed considerable inhibition of other microbes used. The MIC was also calculated. The extraction was carried out using Soxhlet and the extract was spray dried. The extracts were then analyzed using HPLC. The spray dried extracts were used along with fruit peel powders to fortify cookies, jams and cheese. The nutrient content and quality of these products were analyzed. An attempt is being done to encapsulate the extracts so it can be consumed as concentrated forms. The health benefits of this combination on humans on longer run needs to be analyzed. With a stagnant spice productivity and tight competition from the other producers, it's time to look around to present the age old flavours, a different value addition (functional foods).

SESSION I



Spices – Global production and trade scenario

ORAL PRESENTATION

S1 OP1

Spices and flavours of Andaman & Nicobar Islands–Status and way forward

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Andaman & Nicobar Islands, India are a group of 572 Islands (of which only 38 are inhabited) located in the Bay of Bengal between 6°-14° N latitude and 92°-94° E longitude as a long and narrow stretch having warm tropical weather conditions with a temperature ranging between 22°-32°C, high relative humidity (70 to 90%) and mean annual rainfall of about 3000 mm. Over 86% of the island areas are covered by natural forests and about 46000 ha is under cultivation of various crops predominated by coconut and arecanut plantations in about 27000 ha. The agro climatic conditions of these islands are considered highly suitable for growing several spice crops and there is a lot of scope to increase the production and productivity of spices in the islands as intercropping in the plantations. The major spices grown are black pepper, clove, cinnamon, ginger and turmeric. The Islands are also known for their unique diversity of spices and aromatic crops (both cultivated and wild) such as *Piper*, *Myristica*, *Curcuma*, *Zingiber*, *Syzygium*, *Cinnamomum*, *Amomum*, *Vanilla*, *Capsicum*, *Garcinia* and many more underutilized minor spices crops. The potential of spices cultivation in the islands are considered under-exploited although it is grown in pockets. The strategies for exploiting the natural diversity and increasing the Island spices includes, establishment of modern nurseries, inter/mixed cropping, establishing the superior quality of spices from islands, selection of better varieties from the diverse island spices, promotion as organic island spices targeting the tourism sector. The aromatic crops such as lemon grass, mentha, palmrosa, vetiver and *Ocimum* are also suitable to be grown. The spices and aromatic crops cultivation has the potential to transform the Island agriculture to more profitable one as most major spices could be produced under these conditions with ease. Establishment of oil extraction units and promotion of aroma therapy with locally extracted essential oils, coconut oil and noni products has tremendous potential. The present area of spices and aromatic crops (over 1800 ha) could be easily tripled in another five or six years if concerted efforts are made to integrate the cultivation of different suitable spices in the existing coconut and arecanut plantations. The paper covers the species diversity, research avenues in improvement of spices, improved varieties identified as better for island conditions, promotion of newer spices from islands, issues in spices cultivation, cropping systems, scope for value addition, quality of spices and aromatic crops grown under Island conditions and marketing avenues to promote Island spices.

S1 OP2

Producing tropical spices for global markets: Structural changes and emerging trends in sources, trade and destinations

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Spices form a group of highly traded agricultural commodities in the world with an estimated trade value of 12 billion US dollars in 2018-19. The tropical spices like black pepper, ginger, nutmeg and cardamom are consumed in a large number of countries who do not produce them at all. With the opening up of trade consequent to WTO agreement, the production and trade of spices, a typical domain of developing countries, have undergone significant changes. Understanding these changes is important in crafting policies for equitable development of spices sector.

We undertake a detailed analysis of these changes. The study was conducted across seven major spices (Black pepper, ginger, turmeric, nutmeg, cardamom, cinnamon and clove). Using the time series data on spices production from FAOSTAT and trade of spices from UN Comtrade database for over three decades, we analyze the changes in concentration of production of spices across the globe among spice production zones. Herfindahl index is used for studying these changes. The diversification of import sources, which follows as a corollary to these changes in export diversification is also studied. The trends in trade among the producing countries as a share of their total exports of spice commodity serves as an indicator of intra trade among producing countries. Using the Grubel-Lloyd index, the intra industry trade quantum is measured. The movement of the index is used to identify the changes in trading status of producing countries of tropical spices.

The study clearly brings out evidence for three major trends in tropical spices *viz*, the increasing diversification of production, the increasing trade of tropical spices between producing countries and rising level of Intra industry trade. The Herfindahl index for black pepper declined by 31 per cent over a period of three decades indicating significant diversification in country wise global supply. Similar trend was observed in other tropical spices also. The trade between producing countries in tropical spices has increased significantly since 1990's with the trade value increasing more than 50 per cent for turmeric, black pepper, cinnamon and clove within a period of two decades. The analysis also brings out the structural changes in spice trade of individual countries. The rising intra-industry trade in spices for India, the leading exporter and importer of spices, is illustrative of the general trend in the spice producing developing countries in tropical regions.

Each of the identified trends hold significance as they indicate a fundamental change in the way spices are traded in global markets. The changes in sources, the increasing competition among producing countries and increasing instances of market uncertainties underlines the need for better coordination and cooperation among the producing countries to influence the terms of trade in their favour. The paper outlines the policy options at a multinational level for addressing some of the adverse trends in the global spice markets like the need to establish intra-governmental parastatals and planned production horizons.

SESSION I



DIGITAL POSTER PRESENTATION

S1 P1

Price transmission and supply response: The case of Indian small cardamom

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Price formation and transmission between Indian and international markets and the supply response of small cardamom to changes in price were analyzed. The co-movement between the cardamom prices in the Indian and international markets was confirmed in the post-WTO period(1995-2018), while there was no integration in the pre-WTO period (1983-94). The transmission of price signals between Indian and international markets was also established for period I (1983-90), period III (2001-10) and period IV (2011-18). The price series of different grades of cardamom in the domestic market were found to be moving together in almost all the periods considered. Thus, the price of cardamom in one market was found to considerably influence the price prevailing in the other market after the liberalization of trade. The Error Correction Model (ECM) indicated the presence of short-run disequilibrium between the Indian and international prices and between the prices of different grades of cardamom, which got corrected with varying speed of adjustment. Granger causality test confirmed that the price transmission was from the international market to the Indian market in the long-run. The elasticity of supply of small cardamom with respect to its own price lagged by two years was positive and significant in both the short-run (0.39) and long-run (0.96). The excessive volatility in the prices of small cardamom could be tackled through crop specific price stabilization mechanism and by bringing more transparency in the e-auction system, which could reduce re-pooling by traders.

S1 P2

Economic analysis of growth and instability of Indian green cardamom's export (quantity, price and unit price)Subin Thomas*, Nahar Singh, Ashish Samarjit Noel & Jaaziah P John¹

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The growth and instability in terms of export quantity, export price and export unit price of green cardamom were investigated. During pre-WTO period (1986-87 to 1994-95), export value of green cardamom registered a negative growth of (-) 39.81 which decreased from Rs.18.49 crores during 1986-87 to 7.62 crores during 1995-96 and export quantity decreased from 1447 tonnes to 257 tonnes at the rate of (-) 11.80 per cent over the years. A negative growth of (-) 31.75% was observed in unit value was realized and found insignificant. During the post-WTO period (1995-96 to 2017-18), quantity of green cardamom export witnessed a growth of 12.81%. The value and unit value of green cardamom increased at the rate of 18.63 and 5.15% over the period. Looking at the results for the overall study period, the growth rate to the tune of 8.81% was observed in the export quantity of green cardamom. Instability in export quantity of green cardamom was higher in pre-WTO

period (10.72, 52.40 and 49.21%) than both post-WTO (6.86, 26.86 and 39.41 %) and overall (9.39, 36.08 and 61.57%) periods. Instability index of export value of green cardamom during pre-WTO period (15.15, 90.87 and 206.02) was higher than both post-WTO (6.97, 23.44 and 49.21%) and overall period (15.09, 52.18 and 197.225%). In the case of export unit price, the instability was more in pre-WTO period (37.07, 93.28 and 221.20%) when compare to both post-WTO period (15.36, 45.30 and 20.43 per cent) and overall period (35.51, 52.18 and 181.53%). The export quantity, export price and export unit price of green cardamom showed a positive and increasing compound growth trend in post-WTO period. The variability in export value of Indian green cardamom was very high during pre-WTO period compared to post-WTO period.

S1 P3

Agriculture practices for ginger farming in north Karnataka: A case study

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A migratory farming practice by Kerala farmers was witnessed over the past decade with enhanced cultivation in neighboring states, which contributed to an upswing in domestic ginger production. A preliminary survey was conducted in selected ginger growing fields around Jhamkandi taluk of Bagalkot District, Karnataka. Farmers from this region received a net profit of minimum 6.0 lakh INR per acre by investing approximately 1.0 to 1.5 lakh INR for its production on land with average 5-6 acreage. Here the investment is three times less than the total profit. Towards ensuring yield, farmers apply macro and micro nutrients at their optimum level through drip irrigation every three days after 45 days of initial germination. The basal dose applied per acre includes DAP 2 bag, MOP 2 bag, magnesium sulphate 25 kg, zinc 10 kg, ferrous 10 kg, sulphur 15 kg and boron 2 kg. Various agrochemicals that are used for crop protection include Ridomil, copper oxychloride etc. Besides for control of soft rot and bacterial wilt, proper water channel systems are made between the beds that minimizes infection and in the event of any infection accounts for <5% loss. Once harvested, the field is not used for ginger cultivation for a minimum of three years and instead alternative crops like sugarcane, watermelon and groundnut are sown. The huge profit made by these farmers is a result of agriculture practices like drenching, application of cow dung based bio-fertilizer, drip irrigation and water management.

S1 P4

Problems and prospects of turmeric growers in Onattukara region, Kerala, India

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The present study assessed the constraints faced by the turmeric growers in the Onattukara region of Kerala. The variables taken under study were socio-economic profile of the growers, farming experience, operational landholdings, area under which turmeric is cultivated, annual production and constraints of cultivation. The major constraints encountered by the growers were climatic changes and natural calamities (98.89), annually

declining turmeric yield (97.78), high wage rate for labourers (95.56), private dealers' exploitation (52.22) and non-remunerative price for the produce (51.67). The study exposed the knowledge of the growers to various pre-and post-harvest practices. Results of the work pointed out the major constraints faced by the growers in the region especially in production and marketing areas.

S1 P5

Nutmeg economy in India: Status and Future Scope

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In nutmeg cultivation, the trend analysis revealed that area and production in Kerala exhibited an increasing trend and the productivity, a varying pattern. Although the growth rate in area is 4.43% per annum, the production increased only by 2.15% due to the decline in productivity by 2.17%. The productivity was not moving in tune with the increasing area and production due to perennial nature of the crop; newly planted areas were under the pre-bearing and yield increasing stage. The export of mace from India, both in terms of quantity and value has increased over years; the increase was much higher during the initial years of 2000. From 2003 to 2017, quantity of export increased only by two times whereas the value increased by nine times, indicating a higher growth in unit value. The import quantity of mace has increased from 53 tonnes in 1988 to 1779 in 2017, whereas the value of imports drastically increased from 222 US\$ to 18,439 US\$. Nutmeg price in the domestic market has shown considerable volatility due to increasing imports and declining exports over the years. Limited flexibility in the cropping pattern of trade dependent perennial crops like nutmeg resulted in income volatility. Due to increased risk farmers are dissuading from carrying out further investments in nutmeg cultivation.

S1 P6

Seed spices: The emerging leader for spice sector in India

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Since 1985 the acreage under spice cultivation has increased to more than double from 18.82 lakh to 40.86 lakh ha in 2018-19 at CGR of 1.64 % per annum. During this period, seed spice cultivation has outpaced other spices in the country. The area share of seed spices to total spices is continuously increasing, from less than one third (31%) in 1980s to almost half (49.12%) during 2018-19. Role of seed spices in spice economy of India has increased because there are high remunerative and less input demanding crops. Therefore, diversification to high value low volume seed spices is paying more returns to the farmers. From the cultivation of cumin, coriander, and fennel farmers can earn an average net returns of more than 40000, 50000 and 60000 rupees per ha, respectively with input-output ratio of 1:1.7, 1:1.9 and 1:2 over cost C2, respectively. Seed spice cultivation yields higher returns compared to traditional high volume crops in respective area of cultivation. Therefore, in an endeavor to double the farmer's income by 2022, diversification towards

seed spices with value addition through processing is highly advocated. The contribution of seed spices in total spice export earning is also increasing over the period where share of seed spices has increased to more than double from less than 8.0% in 1995-96 to more than 18.0% in 2017-18.

S1 P7

Prospects of cultivation of Kashmir saffron (*Crochus sativus* L.), chillies and Kala zeera (*Bunium persicum* Bioss.) in Jammu and Kashmir Union Territory (UT)

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In the present study, prospects of sustainable cultivation of saffron, Kashmir chillies and Kala zeera in Jammu and Kashmir union territory was ascertained. The surveillance for pests, diseases and natural enemies in Kashmir saffron, chillies and Kala zeera was undertaken in farmer's fields located in Pampore, Pulwama zone of Kashmir valley. In saffron, the major pests recorded were thrips *viz.*, *Anaphothrips* spp., *Thrips flavus* and *Microcephalothrips abdominalis*, saffron bulb mites (*Rhizoglyphuse chinous*), plant parasitic nematodes (*Meloidogyne* spp.) and vertebrate pests i.e., rodents (*Pitmys* spp. and porcupines). The major diseases recorded were saffron corm rot caused by *Fusarium moniliformae* and the sclerotial rots caused by *Sclerotium rolfsii*. The natural enemies recorded were hymenopteran parasitic wasps (*Apanteles* spp.) and spiders. During full blooming season, activity of hymenopteran pollinators was also recorded. In Kashmir Chillies, infestation of thrips (*Scirtothrips dorsalis*), aphids (*Aphis gossypii*) and mites (*Polyphagotarsonemus* spp.) were recorded. In Kala zeera, the major pests recorded were aphids (*Myzus persicae*) and cutworms (*Spodoptera* sp.). The major diseases recorded in Kashmir chillies and Kala zeera were powdery mildews and wilt (root wilt). The pests and disease surveillance results revealed that the major and minor pests and diseases incidence recorded were less than 10% (below ETL).

S1 P8

Saffron: Commercialization, limitation and prospects

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The present area under saffron is 3715 ha, with the production and productivity of 16 MT and 5 kg per hectare, respectively. National requirement of saffron is 100 MT which indicated a deficiency of 84 MT. This deficiency can be overcome by both vertical and horizontal expansion in the traditional and nontraditional areas. In J&K, the potential areas under saffron cultivation are 12000 ha. The present requirement of planting material is 60000 MT. The available planting material is approximately 19000 MT. The main limitation is the deficit of 41000 MT of planting material (corms). To overcome this, development of potential public sector nurseries in nontraditional areas is the need of the hour. Secondly the popularization of already standardized tissue culture protocol of SKUAST-Kashmir

among industrialists for development of quality planting material. Adoption of production technologies developed by SKUAST-Kashmir is necessary for better commercialization of saffron. Among the biotic stresses, it is estimated that the losses due to corm rot leads to yield loss of up to 30-40%. To reduce the yield losses, use of biocontrol agents, biofertilizers and fortified organic manures are applied.

S1 P9

Intercropping of spices in plantations and orchards: Success stories

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Growing spices in the existing cropping systems is an emerging trend. Mr. Deepak Gopal Sawant, a 62-year-old farmer from Ratnagiri District planted Banavali variety of coconut on five acres of land during 2002. During 2008, intercrops such as black pepper (Panniyur1), nutmeg (430 plants of Swad, Sugandha and Shreemanti) and 140 kokum (Konkan Amruta) were planted along the borders adopting recommended package of practices. The economics to maintain one hectare of system was approximately Rs. 220000 to Rs. 230000 per annum. Average net return realized from all crops was Rs. 5.75 lakhs to Rs. 6.55 lakhs/ha per year. Another farmer Mr. Pravin Joshi Kharawate of Ratnagiri established a mixed cropping system in coconut garden under 1 ha area by planting black pepper, nutmeg and cinnamon under the technical guidance of Dr. BSKKV, Dapoli realizing an average turnover of Rs. 2-2.5 lakhs/ha. Mr. Vasant Udeg from Chiplun planted black pepper (Panniyur1) as intercrop in well-established mango orchard in 2012 in an area of 2.5 ha. The black pepper was trained on trunk of bearing Alphonso mango trees. The farmer gets additional Rs. 2 lakh income from the black pepper. Mr. Raj Bhargaw Padhay from Nate Rajapur had plantations of Alphonso mango (2 acres), arecanut (1 acre) and rice (2 acres). He planted black pepper as intercrop in arecanut on 0.5 acre. His annual income is Rs. 1.5 lakh rupees. Dr. Anil Joshi Narwan from Guhagar has mango plantations with Alphonso variety. He planted black pepper vines on the trunk of bearing Alphonso mango trees. His income from black pepper trained on mango is nearly Rs. 75000 per year. He also planted Konkan Sugandha and Konkan Shrimanti (nutmeg varieties) as intercrop in coconut orchard and obtaining Rs. 1.5 lakh as additional income. Intercropping increases the resource use efficiency and gives stability in terms of productivity and income and this diversified cropping is need of the hour.

S1 P10

Spices: Valuable intercrops in mature oil palm gardens

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An experiment was conducted to identify suitable spice cum medicinal plants/crops for mature oil palm gardens. The growth and performance of spice cum medicinal crops *i.e.*, turmeric (*Curcuma longa*), mango ginger (*Curcuma amada*), black turmeric (*Curcuma caesia*),

white turmeric (*Curcuma zedoaria*), wild turmeric (*Curcuma aromatica*), Indian arrow root (*Curcuma angustifolia*), ginger (*Zingiber officinale*), red ginger (*Zingiber officinale*), black ginger (*Kaempferia parviflora*), galangal (*Kaempferia galanga*) and bitter ginger (*Zingiber zerumbet*) in mature (16 years old) oil palm garden were evaluated. The studies revealed that, mango ginger (15.36t), wild turmeric (8.22t), Indian arrow root (7.85t), white turmeric (7.12t), turmeric (6.85t) and ginger (6.84t) recorded good yield as compared to black turmeric (5.56t), bitter ginger (3.92t), red ginger (3t), galangal (2.1t) and black ginger (1.82t). Average light infiltration in intercropped area was 276 μ moles/m²/sec or 23.78%. Among the crops, maximum volatile oil (3%) and oleoresin (16.6%) levels were recorded in turmeric. Curcumin content recorded in turmeric was 3.46%. Chlorophyll content in leaves was higher in ginger (3.45mg g⁻¹) whereas lower chlorophyll was noticed in red ginger (1.02mg g⁻¹). Based on the results, promising crops like mango ginger, turmeric, ginger, Indian arrow root, white turmeric, wild turmeric and black turmeric can be grown commercially in mature oil palm gardens.

S1 P11

Value chain approach for promotion of spice farming systems in Paderu tribal agency area, Visakhapatnam

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Vishakhapatnam is identified by the NITI-AYOG as Aspirational District in the state of Andhra Pradesh. Out of three Divisions *viz.*, Vishakhapatnam, Narasipatnam and Paderu in the district, a major proportion of tribal communities (89.98%) are dwelling in Paderu Tribal Agency area. The ICAR-Indian Institute of Spices Research implemented a multi institutional project leveraging several technologies developed by the Institute for immediate benefit to the tribal community at Paderu. The major impact was recorded due to two interventions namely, improved varieties of turmeric (Roma and IISR Pragathi) and mechanization of primary processing in turmeric. During two seasons, the average yield for local cultivar was 3 MT of dry turmeric and 8 MT for Roma. The variety spread over an area of 1300 ha. An area of 1483 ha of turmeric involving 1,050 farmers organized under two FPO's were brought under organic cultivation adopting the technologies developed by ICAR-IISR. A master black pepper nursery was established at Chintapalle with six thousand cuttings of eight improved varieties of black pepper developed by ICAR-IISR. About 1,45,000 cuttings were distributed to the tribal farmers during two seasons. Under the area expansion programme of state ITDA, area under black pepper registered an increase from 10,378 acres in 2015 to 56,378 acres in 2019. The significant innovative outcomes were spread of improved varieties in turmeric, replacement of traditional practice of 2-3 seasons turmeric cultivation in the same land with one season cultivation and adoption of farm machinery for primary processing in turmeric.

SESSION II



Spices – Chemistry and functional foods

ORAL PRESENTATION

S2 OP1

Phyto-constituents profile in turmeric (*Curcuma longa* L.) genotypes under multi environmental conditionS Aarthi^{1,2*}, J Suresh², D Prasath¹ & N K Leela¹¹ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala, India²Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

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The phyto-constituents of turmeric add nutritive and medicinal value to the crop and used as a phyto medicine since ancient time. Chemical constituents of turmeric rhizomes include volatiles and non-volatiles. In present investigation the phytoconstituents of turmeric essential oil and total curcuminoids (bisdemethoxycurcumin (BDMC), demethoxycurcumin (DMC) and curcumin (CUR)) were analyzed in 15 genotypes representing major turmeric grown regions of India and evaluated in three different environments to study the genotypes and environmental influence on the constituents. The results revealed that the genotype, IISR Prathiba recorded the highest curcumin content and was on par with SLP 389/1, IISR Pragati, Duggirala Red, Rajendra Sonia, BSR-2, CO-2 and Punjab Haldi-1. Among curcuminoids, curcumin was recorded high in all genotypes except Acc. 849 and Narendra Haldi 98, where DMC was more than CUR. Stability model using AMMI revealed that IISR Prathiba and BSR-2 recorded stable BDMC content and SLP 389/1, Acc. 849 and CO-2 recorded stable DMC content across the environments. Stable genotypes for curcumin (CUR) were BSR 2, CO-2, IISR Prathiba and Duggirala Red. The GCMS analysis for essential oil constituents of 15 genotypes revealed that the major volatile compounds obtained were zingiberene, β -sesquiphellandrene, ar-turmerone and curlone (β -turmerone). IISR Prathiba and Duggirala Red recorded high ar-turmerone + turmerone. Zingiberene was recorded high in Acc. 849 and Narendra Haldi 98. Curlone was recorded high in SC 61 and Rajapuri. The minor compounds identified based on GCMS were α -phellandrene, 1,8-cineole, α -terpinolene, α -santalene, α -bergamotene, caryophyllene, β -santalene, β -farnesene, α -humelene, α -curcumene and β -bisabolene. α -santalene was recorded high in Megha Turmeric 1 and Suvarna. The compound α -humelene was recorded high in Acc. 849 followed by Narendra Haldi 98 compared to other genotypes. Identification of phyto constituents stable genotypes and favourable location for cultivation with respect to curcuminoids and essential oil constituents may help the farmers and industries to cultivate specified variety based on the need.

S2 OP2

Effect of non-thermal plasma processed air on essential oil yield, extraction efficiency and its subsequent effect on flavor compound of *Cuminum cyminum* seed

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Atmospheric pressure cold plasma application in the form of plasma processed air bubbles at the solid-liquid phase is a nonthermal cutting edge technology for spice processing to retain its flavors and fragrances. *Cuminum cyminum* is a regularly consumed spice with

significant medicinal properties and also contains essential oil (2% to 5%) that imparts the characteristic aroma to the seeds. This study investigated the influence of plasma processed air through bubbling in solid-liquid medium at different voltage (175, 180 and 185 V), exposure time (30, 60 and 90 min) and particle size (whole seed and 0.5 mm sieve size powder) on the essential oil content and its subsequent effect on flavor compounds. The essential oil yield was determined by hydro-distillation and its flavor composition was analyzed using the GC-MS technique. The results indicated that with increase of voltage and exposure time, both oil yield and extraction efficiency of essential oil increased from 2.67% to 3.79% and 53.4% to 75.8% for 0.5 mm particle size and 4.46% to 4.9% and 89.2% to 98% for whole seeds (in comparison with control) respectively. There was also a considerable change in the percentage of flavor compound retained in the essential oil of control and treated cumin. Thus, plasma application in the spice industry plays a promising role under essential oil extraction yield.

S2 OP3

Chemical compounds of medicinal importance in herbs and spices for health benefit

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A study was undertaken to chemically characterize the medicinal herbs and spices germplasm collected from different parts of India. The variation in active constituents and different chemotypes identified for high medicinal value of these herbs has been highlighted in this paper. The important herbs and spices chemically characterized and found rich in aroma compounds were *Oregano vulgare* (Carvacrol, Thymol), *Oregano marjorana* (Cis - Sabinene hydrate), *Ocimum basilicum* (Methyl chavicol, Linalool, Methyl cinnamate), *Ocimum citridorum* (Neral, Geranial), *Rosmarinus officinalis* (α -Pinene, Camphor, 1,8-Cineole), *Lavendula officinalis* (Linalool, Linalyl acetate), *Lavendula stoechas* (Camphor), *Salvia officinalis* (α , β -Thujone), *Thymus serpyllum* (Thymol), *Cymbopogon flexuosus* (Citral), *Coriandrum sativum* (Linalool) and *Trigonella foenum-graecum* (Diosgenin). Therefore, aromatic plants and their extracts/oil have the potential to become new generation substances for human nutrition and healthcare.

S2 OP4

Negative pressure extraction of essential oil from lavender: Kinetics and modelling

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Extraction is known among the primary known chemical operations and constitutes a vital process for the recovery and purification of active compounds from plant biomaterials. Most of the extraction processes take a considerable time, are laborious, utilize costly and environmentally hazardous organic solvents, cause degradation of various thermolabile compounds and high maintenance charges. Emerging technologies such as microwave (MW) assisted extraction, ultrasonic (US) assisted extraction, supercritical fluid (SF)

extraction, and pulsed electric energy (PEE) assisted extraction and accelerated solvent extraction, have been successfully used. These technologies aim to reduce the use of organic solvents, decrease the treatment time, increase the yield of extraction, reduce the processing temperature intensifying the mass transfer process, and reducing the energy consumption. One such technology is Negative pressure cavitation (NPC) extraction. It is a type of hydrodynamic cavitation method. In NPC, under negative pressure created by a vacuum pump, an intense cavitation is formed to corrode the surface of solid particles. The turbulence, collision and mass transfer between the extraction solvent and solid matrix are increased when air is continuously added into the system which facilitates the migration of target compounds out of the sample matrix. This novel, environmentally friendly green technology, and efficient extraction technique using negative pressure cavitation (NPC) has been successfully applied to extract essential oil from lavender. This paper explains the process optimization of the extraction of essential oil from lavender.



DIGITAL POSTER PRESENTATION

S2 P1

Assessing the phytochemicals and bioactive compounds of select South Indian black pepper (*Piper nigrum* L.) varieties and types

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The chemical composition of black pepper (*Piper nigrum* L.) essential oils isolated from matured dry berries of 18 accessions was evaluated by gas chromatography-mass spectrometry (GC-MS) analyzer. The essential oil was extracted by hydro-distillation that varied from 2.30–5.00% among the accessions. Based on the study, 41 constituents accounting 98.26–99.99% of the total essential oil were identified. The main fractions were found to be monoterpenes (61.00–81.65%), sesquiterpenes (16.83–37.49%) and phenylpropenes (4.14%). Among the monoterpenes, the predominant constituents were sabinene followed by 3-carene, D-limonene, α -pinene, β -phellandrene, α -phellandrene, and α -thujene. Caryophyllene was the major sesquiterpene constituent followed by hedycaryol, β -bisabolene, α -selinene and α -copaene. The highest sabinene and caryophyllene was recorded from the accessions Irumbirakki and ACC53 respectively. Across accessions, Panniyur 4 had higher β -pinene (14.17%) and D-limonene (24.16%), whereas the most popular local cultivar Karimunda had greater quantity of 3-carene (24.93%) and α -phellandrene (6.07%). In future, the major bioactive constituents of black pepper essential oil (BPEO) may find greater opportunity in various fields like, food, perfumery, aroma and pharmaceutical industries.

S2 P2

Biochemistry and anatomy of abscission in black pepper (*Piper nigrum*) reveals differential involvement of reactive oxygen species in leaf and spike abscission

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An attempt was made to characterize the abscission process in black pepper using physical, biochemical and histological analysis of the abscission zones (AZ) of both leaf and spike, with anticipation that the mechanistic difference in abscission of leaf and spike could be useful for developing a chemically induced harvesting method. The salient findings of the study are (a) As the ripening progress the detachment force (DF) reduces significantly and the reduction in DF was more in case of spike than that of berry; (b) Protein and reducing sugar content increased gradually as the ripening of leaf, spike and berry progressed. There was a perfect correlation between the protein content of spike abscission zone and berry abscission zone indicating the effect of protein and sugar translocation to berry during maturity; (c) Ruthenium red staining coupled with toluidine blue staining was effective

in visualizing Leaf AZ, while Phloroglucinol staining was successful for observation of spike and berry AZ. (d) The involvement of Reactive oxygen species (ROS) is more in case of leaf for its abscission than in case of spike indicating differential involvement of ROS in the abscission of both leaf and spike. This difference can be capitulated for developing a chemically induced method of harvesting, wherein, use of antioxidant along with commercially available abscission inducer viz. Ethrel might result in differential shedding of spikes.

S2 P3

The discovery of peppery aroma compound 'rotundone' backbone genes from black pepper

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Rotundone, an oxygenated sesquiterpene was recently identified as compound responsible for the peppery aroma of the Shiraz wine grape variety. The importance of the rotundone in the flavor industry warrants search for the precursor genes in plants. We report in this study the identification of rotundone backbone genes viz., α -guaiene synthase & α -guaiene 2-oxidase in black pepper. We identified the precursor genes of rotundone using berry transcriptome profiling. The metabolite profiling using head space LC-MS ensured the presence of the direct precursor compounds for rotundone biosynthesis in black pepper berries. The successful identification of the genes and compounds of the guaiene skeleton is expected to help in bioprospecting of black pepper varieties and also in recombinant production of this aroma compound.

S2 P4

The family of terpene synthases in *Piper* spp. based on berry transcriptome

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Terpenoids are a large class of metabolites attributing fragrance and aroma to *Piper* spp. They are the gateway keepers for primary metabolism and plant defense. The functional diversity of terpenoid is determined by the enzyme group, the terpene synthases (TPS). The present study provides the first annotation of the TPS gene family using berry transcriptome with regard to transcript locus, gene family, and phylogeny from *Piper nigrum* and *Piper longum*.

S2 P5

Volatile profiling during maturation reveals metabolite dynamics in black pepper (*Piper nigrum* L.)P Umadevi^{1*}, T P Ahammed Shabeer², K Anees¹, M Fayad¹, S Shelvy¹ & N K Leela¹¹ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala, India²ICAR-National Research Centre for Grapes, India

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The comprehensive two-dimensional gas chromatography linked to time-of-flight mass spectrometry was employed to study the temporal dynamics in volatile profile in fully mature (FM) and half mature (HM) berries of IISR-Thevam and IISR-Shakthi varieties of black pepper. The proposed technique allowed the separation and identification of more than 70 terpenes and 10 other oxygenated compounds from berries. The compound identification was based on the analysis of deconvoluted mass spectra with a semi-quantitative total ion chromatogram-based analysis. The richest terpene diversity was identified in IISR-Thevam (56 terpenes in FM) followed by IISR-Shakti (49 terpenes in FM). The relative abundance of terpenes was found to vary differently in both the varieties during maturity, wherein terpene fraction found to increase significantly during maturity in case of IISR-Thevam, while an opposite trend was observed in case of IISR-Shakti. The diversity of volatiles was found to increase due to maturity of both the varieties indicating the increased biosynthesis of various compounds during maturity. The terpene fraction found to vary between 79.6 to 97.6% between the varieties tested. In case of IISR-Shakthi, terpinolene was found to be the active component with maximum content (39.0% in FM, 45.0% in HM), while alpha-Ocimene was major compound in case of IISR-Thevam (25.0% in FM and 21.0% HM).

S2 P6

Chemo diversity of selected ginger (*Zingiber officinale* Rosc.) genotypes from Kerala

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In the present study, 122 genotypes of ginger (*Zingiber officinale* Rosc.) were evaluated for the quality attributes namely, essential oil, oleoresin, crude fibre, volatile and pungent components and genotypes with specific quality traits. The Accession No. 282 and 396 were identified as those with highest oil yield (3%); highest oleoresin was recorded in Acc. 282 (10.26%) followed by Acc. 5 (8.39%) and highest crude fibre in Acc. 860 (9.63%) followed by 869 (9.01%). By GC-MS analysis 39 components of essential oil were characterized. Zingiberene (19.34 - 30.08%) was the major component of the oil followed by β -sesquiphellandrene (10.93-14.63%) and ar-curcumene (6.43-10.12%). Acc. 396 was identified with highest Zingiberene (30.08%) and β -sesquiphellandrene contents and Acc. 286 contained highest ar-curcumene. HPLC analysis indicated the presence of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol of which the chief component, 6-gingerol varied between 0.41- 1.7% Acc. 282 with highest oil, oleoresin and 6-gingerol is suitable for industrial use and Acc. 512 with low fibre (3.19%), low oil and oleoresin is suitable for making candies.

S2 P7

Manipulation of macro and micro nutrients on gingerol production and analysis of PAL and CHS gene in microrhizomes of ginger (*Zingiber officinale*) with high gingerol

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In the present study, *in vitro* microrhizomes were induced in modified MS medium by manipulating macro and micro nutrients. The induced microrhizomes were analyzed for gingerol production using High Pressure Liquid Chromatography (HPLC). The role of *Phenylalanine lyase* (PAL) and *Chalcone synthase* (CHS) gene in gingerol production was analyzed through Real Time PCR. The microrhizomes induced in MS medium with twice the micronutrients accumulated highest total gingerols of 0.970 per cent. The microrhizomes induced in MS medium with half ammoniacal nitrogen recorded highest total gingerols of 1.102%. A higher accumulation of 53.53% of total gingerols was recorded in Modified MS (MMS) medium containing twice micronutrients along with half the concentration of ammoniacal nitrogen as compared to control MS medium. Enhanced expression of PAL gene was observed in microrhizomes induced in MMS medium recording 1.137 fold increase over the control. The CHS gene from microrhizomes induced in MMS medium showed an increased expression of 1.392 fold over the control. The study reveals that a simple strategy of manipulation of nutrient composition of MS medium can be adopted for scaling up of gingerol production.

S2 P8

A novel o-methyltransferase gene from *Curcuma longa* L.: A putative structural gene regulating curcumin biosynthesisP Prashina Mol^{1,2*}, R S Aparna^{1,2}, T E Sheeja¹ & K Deepa¹¹ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala, India²University of Calicut, Malappuram, Kerala-673635, India

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Turmeric, one of the widely used spices and herbal medicines, is rich in biologically active curcuminoids, a phenylpropanoid derivative. Biosynthesis of curcuminoids is catalysed by O-methyl transferases through single and double methylation of the hydroxyl group of bis demethoxycurcumin, to form demethoxycurcumin and curcumin respectively. Using a comparative transcriptome approach involving rhizomes from a high curcumin variety (IISR Pratibha) (curcumin content-6.52%) and the same variety subjected to nutrient stress (curcumin content-1.52%), a total of thirty-three O-methyltransferase unigenes were identified. Expression levels varied greatly among the thirty-three unigenes and fold changes within a range of 10 to -4 was observed. Two transcripts (*Clomt1* and *Clomt2*) showing high (108.08, 37.67) and low (3.5, 1.23) FPKM values under contrasting curcumin levels were taken for further study. Tissue specific RT-PCR analysis of *Clomt1* showed thirteen-fold expression in rhizome followed by leaf (~1 fold) and pseudo stem (~0.5 fold), while *Clomt2* showed eight-hundred-fold expression in rhizomes, six-hundred-fold expression in leaf and thirty-seven-fold expression in pseudo stem with root taken as control in both cases. Both the genes were amplified and cloned from genomic DNA as well

as cDNA, blastn analysis of *Clomt1* indicated the unique status of *Clomt1* with maximum homology of 71% with *Phoenix dactylifera* trans-resveratrol di-O-methyltransferase while *Clomt2* showed 98% similarity with the already reported coffee acyl coenzyme A-3-O-methyltransferase from *Curcuma longa*. Sequence analysis showed that *Clomt1* is an intron less gene where as *Clomt2* contains five exons connected by four introns. Moreover, expression analysis *vis a vis* accumulated curcumin content under different developmental stages and environmental conditions revealed significant correlation with the metabolite, suggesting that the identified O-methyltransferases are putative candidates of the biosynthetic pathway for curcumin.

S2 P9

Biochemical elicitation induced by exogenously applied Chitosan in *Curcuma aromatica* Salisb.

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The biochemical responses induced by exogenous application of chitosan in *Curcuma aromatica* has been illustrated in the study. The experiments were laid out in completely randomized block design with seven treatments and three replications. The chitosan at different concentration (0.0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 g L⁻¹) prepared in acetic acid 0.25% solution were applied as foliar spray at three and five months after planting. The chitosan application at 3 g L⁻¹ resulted in 73.0% increase in curcumin content and 68.0% increase in oleoresin over the control treatment. The chitosan foliar spray at 2.5 g L⁻¹ showed 59.0% increase in volatile oil over the control.

S2 P10

Extraction and characterization of individual curcuminoids from different cultivars of *Curcuma longa* L.

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Curcuminoids in turmeric powder contain curcumin (C), demethoxycurcumin (DMC) and bis-demethoxycurcumin (BDMC) in approximately 70-75, 20-18 and 10-7%, respectively. The pigment curcumin is industrially produced using turmeric oleoresin as the starting material. Crystallization of curcuminoids from turmeric oleoresin usually offered curcumin (C) in 85-88% purity. Since the curcuminoid pigments vary in chemical structures, it is possible that the physico-chemical characteristics as well as the functional properties would vary among them. As DMC and BDMC are not commercially available, it could be important to obtain these pigments in high purity for detailed studies on their chemical and physiological attributes. Hence, the present study relates to establishment of individual curcuminoids profile of different cultivars (lakdong, Prathiba, Wygon, Cudapha and Burma) by HPLC. The results revealed that curcuminoids range among the varieties, C (50.0 to 70.0%), DMC (20.0 to 30.0%) and BDMC (10.0 to 20.0%) by HPLC.

S2 P11

Leaf curcumin: A surrogate measure for rhizome curcumin content in turmericK Giridhar^{1*}, S Suryakumari² & N Hariprasad Rao¹¹Horticultural Research Station, Dr. Y.S.R. Horticultural University, Guntur-522 034, Andhra Pradesh, India²College of Horticulture, Dr. Y.S.R. Horticultural University, Chinnalataripi, Andhra Pradesh, India

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The screening for curcumin content in vast number of genotypes is very cumbersome and time taking process. Long cropping period, curing of rhizome and cumbersome analysis are major hurdles in identification of superior types for curcumin. One cycle of such evaluation takes almost a year, is quite difficult to screen large number of genotypes. In a particular study on cv. Mydukur, it was observed that curcumin content of rhizome at harvest was significantly correlated with protein content of whole plant at 150 DAP (0.71**) and 180 DAP (0.72**). It was also significantly correlated with phenol content of whole plant at 150 DAP (0.88**), 180 DAP (0.72**) and 210 DAP (0.62**). Further, it was also significantly correlated with rhizome protein (0.67*) and phenol (0.67*) content of rhizome content at harvest. Taking cue from this observation, further, a study was conducted on a set of 46 germplasm lines to know the relationship among certain biochemical attributes and rhizome curcumin content. In this study, it was found that rhizome curcumin content at harvest was significantly correlated with ferulic acid content in leaves at 150 DAP (0.77**) and leaf curcumin content at 150 DAP (0.39**), 180 DAP (0.44**) and 210 DAP (0.44**). The aforementioned studies indicated that the curcumin content in whole plant or leaf at 150 DAP was significantly correlated with rhizome curcumin content at harvest. To further refine this approach, a further study was conducted with a set of 52 germplasm lines of turmeric. In this study, it was observed that the curcumin content in leaves at 120 DAP was significantly correlated with rhizome curcumin content at harvest (0.74**).

S2 P12

Profiling of quality and nutraceuticals of geographical indications turmeric in India

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The objective of the present study was to determine the quality and nutritional profiles of four geographical indication (GI) turmeric (Erode turmeric, Kandhamal haldi, Waigon turmeric, Sangli turmeric). Considerable differences were recorded for major quality parameters viz., essential oil (4.00-5.60%), oleoresin (8.36-18.12 %) and curcumin (2.23-5.50 %) among GI turmeric. The colour composition of the samples was studied and recorded in the range of L*(45.68- 52.48), and b*(58.89- 63.69) which were significantly high in Sangli turmeric and a*(21.59- 24.77) was found to be highest in Kandhamal haldi. Further, chemical and mineral composition were analysed and significant levels of K, Ca, Mg was found in Erode turmeric, N was obtained highest in Waigon turmeric. The results pertaining to N, K, Ca, Mg ranged between (0.80- 1.75%), (2.48- 3.19 %), (0.08- 0.50 %) and (0.11-0.45%), respectively. Samples were analysed to find the presence of P, Cu, Mn, Fe, Zn and the results were indicated with significant levels ranged between (0.41- 0.45ppm), (4.63- 6.63 ppm),

(39.6-91.5ppm), (134.3- 251.5 ppm) and (12.3-28.0 ppm) respectively. Waigon turmeric was found to be significant in the levels of Cu, Mn, Zn whereas Fe was significantly high in Erode turmeric. Kandhamal and Waigon turmeric indicated the same quantity of P. Studies on the nutritional properties revealed that Erode turmeric contains appreciably high amount of crude protein (4.64%) and crude fibre (10.40%). Waigon turmeric was recorded with significantly high quantity of carbohydrate (73.7%), total fat (9.16%) and energy (374.53 Kcal 100g⁻¹) while, other parameters such as percentage of ash was reported to be highest in Kandhamal haldi (14.3 %) and fibre (10.40%) was recorded maximum in Erode turmeric. Investigations were carried out to determine the proximate antioxidant activity and found to be the highest 50.0% inhibitory concentration (IC₅₀) in Waigon turmeric (31.51 µg ml⁻¹) whereas in the case of antidiabetic assay highest 50.0% inhibitory concentration (IC₅₀) was in Kandhamal haldi (126.50 µg ml⁻¹). Total curcuminoids using HPLC and essential oil constituents using GCMS were also studied.

S2 P13

Chemical profiling and constituent diversity in a core germplasm of nutmeg (*Myristica fragrans* Houtt.) and the dynamics of fresh and stored volatile oils

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Chemoprofiling of a core nutmeg germplasm revealed significant variation for contents of volatile oil, oleoresin and fixed oil. The range of variation was 1.57 to 7.76% for kernel oil, 2.05 to 9.33% for mace oil, 18.59 to 36.20% for kernel oleoresin, 11.38 to 31.66% for mace oleoresin and 17.79 to 44.80% for fixed oil of kernel. Genotypes, Acc. 8, Acc. 22 and Acc. 38 were recorded as both high yielding as well as of high chemical composition. These three genotypes could very well be categorized as high performing types which could be for cultivation, pharmaceutical applications and industrial purpose. GC-MS analysis of volatile oil exhibited wide variability among the accessions. Total of 20 and 24 compounds were identified from kernel and mace oils, respectively. The total volatile constituents in the genotypes ranged from 68.96 to 90.49% in kernel oil and 83.86 to 93.89% in mace oil. Principal volatile compounds in the essential oils were myristicin (2.98 to 12.84% in kernel oil; 1.57 to 18.87% in mace oil), elemecin (4.31 to 22.48% in kernel oil; 1.39 to 27.86 % in mace oil) and sabinene (1.06 to 11.75% in kernel oil and 4.89 to 16.20% in mace oil). Apart from these, accessions also recorded higher percentages of alpha-pinene, beta-pinene and L-4-terpineol in kernel and mace oils. Based on the per cent composition of volatiles, the accessions were grouped into low, medium and high. Based on the relative content of principal volatile constituents, chemotypes could be utilized in food, cosmetic and pharmaceutical applications. A novel finding on the changes in the volatile oil composition of nutmeg upon storage is also reported. Kernel and mace volatile oils recorded the presence of 27 and 30 compounds after one year of storage as against 20 and 24 compounds respectively in the fresh oil.

S2 P14

Acacia senegal gum as wall material for microencapsulation of cinnamon oil

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Essential oils and food flavours are prone to deterioration in different environmental

conditions such as heat, light and enzymes. This can be overcome by microencapsulation technique, in which phytochemicals are encapsulated in a wall material (encapsulant). Microencapsulation enhances the shelf life, stability, handling and flow properties of the product. Exudate gum of *Acacia senegal* has unique properties of emulsification, good volatile retention, low cost, high solubility and low viscosity which make it suitable wall material for microencapsulation. Microencapsulation powder of cinnamon oil with *A. senegal* gum has been produced using spray drying process and characterized by particle size analysis and FTIR. The gum exudate from the bark of *A. senegal* trees was harvested, cleaned and refined before use. A solution of *A. senegal* gum was prepared in distilled water and cinnamon oil was added. The mixture was then homogenized to obtain feed emulsion. A part of the emulsion was kept aside for particle size analysis and rest was spray-dried using different inlet, outlet temperatures and feed rate. DLS particle size analysis was done after diluting the feed emulsion and also after reconstitution of spray-dried powders with distilled water. Encapsulation efficiency was calculated by the determination of surface oil and total oil content of microencapsulated sample by solvent extraction. Spray drying at 205°C inlet temperature, 100°C outlet temperature and feed rate of 12 rpm was suitable to obtain fine microencapsulates. The optimum wall material to core ratio was found to be 4:1. The average particle size of feed emulsion obtained was 1516.2 nm. After spray drying, the particle size of the obtained microencapsulated powder was found to be 6.87 µm. The powder was reconstituted in water to obtain an emulsion of the average particle size of 1005.2 nm. Thus, the spray-dried microencapsulated powder produced stable emulsions on reconstitution. The FTIR spectrum of microencapsulated sample showed a dip in the peak at 1614 and 1415 cm⁻¹ when compared with pure *A. senegal* gum. Thus, *A. senegal* gum can be effectively used in microencapsulation of cinnamon oil. Similarly, there is a scope for evaluation of other natural exudate gums for the microencapsulation of essential oils and flavours.

S2 P15

Evaluation of kokum (*Garcinia indica* Choisy) genotypes for (-)-HCA content in hilly zone of Karnataka

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About 47 kokum (*G. indica*) genotypes were evaluated from the farmers field for (-)-HCA content, (-)-HCA lactone and total (-)-HCA content through HPLC method. The data revealed that percentage of (-)-HCA content in the genotypes ranged from 7.35 to 13.50. The higher percentage of (-)-HCA was found in GI-10 (13.50 %) and lowest (7.35 %) was found in GI-03. The study revealed that the (-)-HCA lactone content in the dried rind of *G. indica* genotypes ranged from 4.85 (GI-14) to 10.81 % (GI-12). Genotype GI-10 (10.26 %) was the next best genotype found with maximum amount of (-)-HCA lactone. The present investigation also revealed that total (-)-HCA content in the evaluated kokum genotypes ranged from 12.28 (GI-14) to 24.18 % (GI-12). Genotype GI-10 (23.76 %), GI-40 (23.22 %) and GI-33 (22.08 %) found with maximum amount of total (-)-HCA content.

S2 P16

Ecology and biochemical properties of local landraces of chillies grown under protected conditions

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To study the ecology and biochemical properties of the popular landraces grown in north eastern region of India, total 13 accessions (6 hot pepper, 3 king-chilli, 2 each of dale-chilli and bird's eye chilli) were collected from the niche area. The ecology of niche area of popular landraces were characterized as cool (11.7–20.7 °C) and humid (>60 % relative humidity) climate (Sikkim and Darjeeling) for dalle-chilli, mild-warm (12.2–28.0 °C) and humid climate (Upper Assam, Nagaland, Manipur and Mizoram) for king-chilli and warm and humid climate (Mizoram, Manipur, Nagaland and Meghalaya and mid-hills of Arunachal Pradesh) for bird's eye chilli during crop period. The accessions were evaluated during February to October, 2020 under naturally ventilated polyhouse having mean temperature (day/night) inside the polyhouse ranged from 22.0 to 27.0 °C/ 15.0 to 20.0 °C, while relative humidity ranged from 47.0% to 68.0%. The biochemical analysis was carried out using ASTA analytical methods. Significant variations were observed for all the traits. Among the landraces the highest average capsaicin content on dry weight basis was observed in king-chilli (4.30%) followed by birds' eye chilli (3.80%), dalle-chilli (3.42%) and chillies (1.53%). Similarly, oleoresin content was also highest in king-chilli (28.98 %) followed by dale-chilli (21.18%), bird's eye chilli (19.21%) and chilli (15.52%). The β -carotene content ($\mu\text{g g}^{-1}$ FW) in red ripe fruits were highest 375.16 in dalle-chilli followed by king-chilli (338.7), birds eye chilli (308.5) and chilli (31.65). Further, antioxidant activities using FRAP (ferric reducing antioxidant power) method was also highest in king-chilli followed by dalle-chilli and bird's eye chilli. The positive correlation was observed between antioxidant activities to capsaicin, oleoresin and β -carotene content. Among the landraces, king-chilli was found superior for both capsaicin and oleoresin content followed by bird's eye chilli for capsaicin and dalle-chilli for oleoresin content under protected conditions. Moreover, the high yielding accessions for yield per plant were identified as King-chilli-1 (819.5 g), SKCC-1 (416.6 g), MZBEC-1(181.0 g) and MLCC-22(332.0g) of king-chilli, dalle-chilli, bird's eye chilli and chilli, respectively. The identified accessions rich in capsaicin and oleoresin content as well as yield can be

S2 P17

Performance of fennel (*Foeniculum vulgare* Mill.) varieties for quality attributes under northern dry zone of Karnataka

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Fennel varieties exhibited significant variation for all the studied yield and yield attributing traits. Among that, the variety RF-281 recorded significantly higher seed yield (30.11 g plant⁻¹, 3432.78 kg ha⁻¹) followed by RF-125 (25.26 g plant⁻¹ and 2890.76 kg ha⁻¹). Fennel

oil content varied between 0.65% to 2.25%. GF-1 recorded maximum oil content (2.25 %) followed by UF-290 (2.00 %), but maximum oil yield was obtained from RF-281 (51.49 kg ha⁻¹). Anethole content ranged from 24.59 per cent (GF-12) to 80.40 per cent (GF-1). From this study we can conclude that, GF-1, GF 12, UF-290 and RF-281 varieties may be exploited in breeding programmes for quality attributes to be incorporated.

S2 P18

Determination of diosgenin and lipid composition of *Trigonella foenum-graecum* seeds

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Diosgenin- a steroidal sapogenin is a major bioactive constituent present in seeds of fenugreek which is most widely used precursor in the preparation of many steroid drugs, sex hormones and oral contraceptives pills. A rapid and sensitive HPTLC method was standardized for quantification of diosgenin in fenugreek seeds. *The results showed that there was wide variation among germplasm accessions for diosgenin content (0.01-0.27%) and fixed oil content (2.2-6.0%). Fenugreek seed oil profiling by GC-MS revealed it rich in polyunsaturated fatty acids of linoleic acid (33.9-50.5%) and linolenic acid (28.8-48.8%). Promising accessions IC321164, IC580108, IC427704, IC572872, IC432022 and IC310625 identified for quality traits may be utilized in developing new cultivars of fenugreek with superior traits. The research on fenugreek exhibits its health benefits due to presence of diosgenin and PUFA imparting it potential medicinal properties.*

S2 P19

Physicochemical characterization and nutraceutical profile of fixed oil from fenugreek (*Trigonella foenum-graecum* L.) seed fractions

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This study has been dedicated to unleash the chemical and physical properties and nutraceutical profile of the fixed oil from fenugreek seed fractions viz., husk and cotyledons. The study aimed at utilizing the fixed oil obtained after defatting the fenugreek seed fractions. The fixed oil was extracted through Soxhlet apparatus using petroleum ether as the solvent. The yield of oil in husk and cotyledon was 2.6 ± 0.2 and 11.6 ± 0.7 respectively. The extracted oil was used to study iodine value 106.98 ± 0.59 and 123.08 ± 1.74 saponification value 274.35 ± 1.35 and 258.73 ± 3.95, and acid value 0.821 ± 0.003 and 2.016 ± 0.005 in husk and cotyledon oils respectively. Color, optical rotation, and refractive index at 37 °C were also evaluated. Characterization of the oil was done with DSC to study its thermal stability up to 300 °C and FT-IR in the range of 400-4000 cm⁻¹ to study its functional groups. Nutraceutical profile of the fixed oil was done to study fatty acids, sterols and tocopherols. Fatty acids profiling of the oil were done by fatty acid methyl ester (FAME) preparation and their constituents were analyzed by gas chromatography-mass spectrometry (GC-MS) to find linoleic acid and α-linolenic acid as prominent fatty

acids. Sterols were identified using spectrophotometer to find β -sitosterol as major sterol and α -tocopherol was the major tocopherol as estimated through HPLC. DPPH and TEAC antioxidant assays were performed to evaluate the antioxidant activity of the fixed oils.

S2 P20

Chemoprofiling and characterisation of unique hill garlic accessions of Marayoor dry hill agro ecological unit of Kerala

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The Marayur Dry Hills agro-ecological unit represents low rainfall, rain-shadow, high hill zone comprising Vattavada, Kanthalloor and Marayoor panchayats of Idukki district, Kerala. The climate is tropical sub-humid monsoon with an altitude of 1700 m above Mean Sea Level. The commercial cultivation of garlic is confined to Kanthalloor and Vattavada panchayaths with annual average production of 630t. The crop production profile reveals the unique practices especially in the Muthuva tribal hamlets. The major cropping season is from April-May and harvest by August- September. There are a few land races which are being preserved by the farming community themselves. The present study was conducted to assess the uniqueness of landraces and to document the same. The traditional local landraces were planted along with twelve released varieties and compared for morphological, yield and chemical characters. Highest equatorial and polar diameters were recorded in Acc. OT (3.90 cm and 3.70 cm, respectively). In the present study, the highest yield of 6.06 t/ha was recorded in Acc. OT collected from Nilgiri hills. The yield from variety, Ooty-1 (5.20 t/ha) and Acc. MPD (5.08 t/ha) collected locally from Vattavada were on par with Acc. OT. In traditional accessions, the bulbs were non radial in distribution and elliptical in cross section. The bulb colour was light pink in Acc. SGP. Gas chromatography coupled with mass spectrometer and a gas chromatograph with flame ionization detector (FID) was used to reveal the chemical composition. The trisulfide, di-2-propenyl and diallyl disulphide were highest in Acc. SGP (53.98% and 37.16%, respectively). Highest concentration of cyclic octaatomicsulfur (3.94%) was recorded in Acc. MPD, which is having the medicinal properties. The per cent of total sulphides were highest in Acc SGP and Acc. MPD. Ascorbic acid content was recorded as highest in Ooty-1 (17.77mg/100g) and the ascorbic acid content of Acc. SGP (15.23 mg/100g) was on par with that of Ooty-1. The Acc. OT was found to be with a highest pungency of 61.12 μ M/g. The essential oil content in Acc. MPD (0.35%), Yamuna Safed-9 (0.35%) and Yamuna Safed (0.34%) were high and the essential oil content of Bhima Purple was on par (0.3%) with these varieties and accession. The allicin content (2.16 to 4.16 mg), total phenol content (48.33 to 82.78 mg per kg) and high percent of total sulphides coupled with long shelf life of 8 to 12 months proves the uniqueness of hill garlic ecotypes in the rain shadow hill agriculture system of Kerala. The crop production system is unique, where in, the bulbs after harvest are heaped in a circular manner with bulb inside and leaves towards periphery. Later they made into bundles with intact pseudostem. These bundles are kept in sunlight for drying and later air dried by hanging it. The rainfed hill agriculture system with a good market network and proximity to tourist hotspot Munnar brings a niche market to the hill garlic with good shelf life and higher levels of secondary metabolites imparting better quality to the produce.

Comparative study of pungency in garlic (*Allium sativum*) genotypes grown under high ranges of Idukki District of Kerala

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An experiment was conducted to compare the quality of different garlic genotypes grown under Idukki agro-climatic condition (Kanthallor and Vattavada panchayats). Nine genotypes *viz.* Yamuna Safed, Yamuna Safed-2, Yamuna Safed-3, Yamuna Safed-9, Bhima Omkar, Bhima Purple, AAS-2, Ooty-1 and Local cultivar from Kanthalloor were selected for the study. Genotypes were planted during May-September 2017 in Kanthalloor panchayat. The area represents low rainfall region having tropical sub humid monsoon climate with an annual temperature of 23.08 °C and rainfall of 1703.7 mm. The determination of pyruvic acid derived from alliin is an indicator of pungency in garlic. The pyruvic acid content ranged from 36.02 $\mu\text{M g}^{-1}$ to 59.48 $\mu\text{M g}^{-1}$ among the genotypes studied. A higher pungency of 59.48 $\mu\text{M g}^{-1}$ was recorded in the genotype Ooty-1 which also recorded a higher yield of 6.93 t ha⁻¹. The pungency as well as yield of local cultivar (57.93 $\mu\text{M g}^{-1}$ and 5.43 t ha⁻¹ respectively) were found on par with that of Ooty-1. The results reveal that some of the genotypes were superior in quality in terms of pyruvic acid content which is an indicator of alliin.

Isolation and analysis of Zerumbone from *Cyperus rotundus* essential oil

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The presence of novel chemical compounds in *Cyperus rotundus* particularly the sesquiterpenes are mainly responsible for bioactive attributes. Zerumbone and cyperone are two major sesquiterpenes found in the essential oil of *Cyperus rotundus* tubers. The aim of our study was to isolate zerumbone, a crystalline sesquiterpenoid cyclic ketone that display various pharmacological activities. We have performed estimation of the moisture of dry powder (14.4%) and hydro distilled it to collect the essential oil. The oil was analyzed by GC and GC MS for zerumbone identification. Essential oil was obtained in 0.5 g per 50 g sample (1.0 % yield). Along with the zerumbone, cyperone was also identified. The minor compounds of the oil are also reported.

SESSION III



Spices – Processing and value addition

ORAL PRESENTATION

S3 OP1

Processing of leafy spices/Herbs: Case study

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The present study was carried out to evaluate the effect of different drying methods on the physico-chemical characteristics (colour, structure, carotenoid and chlorophyll content) and free radical scavenging activity of fenugreek and dill greens. Accordingly, hot air (HA, 40°C, 58-63% RH), low humidity air (LHA, 40°C and 28-30% RH) and radiofrequency (RF, 40°C, 56-60% RH) were explored for efficient drying of fenugreek and dill greens. The three single layer drying models (Exponential, Page and Modified Page) tested showed excellent fit ($R^2=0.92-0.99$) for all the three drying methods. The time required for drying with LHA and RF was lesser (~27%), as compared to HA drying. LHA dried fenugreek and dill had superior green colour and a more porous and uniform structure than those obtained from RF and HA drying. Aqueous methanolic (60:40) extract of fenugreek and dill greens dehydrated by LHA exhibited highest free radical scavenging activity. Dehydrated fenugreek and dill greens showed good consumer acceptance as well as shelf life. Based on the quality (chlorophyll, ascorbic acid and carotenoid retention) characteristics and yield of dehydrated fenugreek and dill greens, LHA drying was found to be superior compared to RF and HA drying. Further, aqueous methanolic extracts of fenugreek and dill greens dehydrated by LHA drying had a noticeable effect on scavenging free radicals. Our findings provide a valuable support for developing a process for dehydrated fenugreek, coriander and dill greens and the usefulness of dehydrated fenugreek, coriander and dill greens (containing phenolic compounds, carotenoids, minerals and antioxidants), as a valuable food additive to enhance nutritive value of the product.

S3 OP2

Effect of curing method and drying temperature on the quality of turmeric flakes

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In the present study, the effect of temperature and curing on the quality of dried turmeric slices were evaluated. Turmeric rhizomes (IISR Alleppey Supreme) of about 3 kg were cured by traditional water boiling method in aluminum pot for 60 min, sliced in a mechanical slicer and dried by spreading on the trays (size of 44.8 × 38.0 cm) of the hot air oven to a drying bed thickness of 5 cm at varying temperatures of 50, 60, 70, 80, 90 and 100°C till constant mass was obtained. Sun drying and solar tunnel drying of turmeric served as control. Another 3 kg of fresh rhizomes were sliced mechanically without curing and dried in the hot air oven at the same drying temperatures. The trays were shuffled alternatively every 2.00 h. Sun drying was carried out by spreading the rhizomes on a clean shade net and the ambient temperature varied between 30°C and 36°C while relative humidity varied from 35% to 61%. Solar tunnel drying was conducted by spreading the sliced turmeric on the trays inside the drying chamber. The temperature inside the solar

tunnel dryer varied between 36°C and 55°C. The loss in mass was recorded periodically and the drying characteristics were calculated. The physical and biochemical properties of the dried turmeric were determined and the quality of cured and uncured sliced turmeric dried at various temperatures was evaluated. The major findings from the above study are summarized as follows. The initial moisture content of the fresh turmeric was 80% and reduced to 2.75% after oven drying at 100°C. Drying time was lower for oven dried turmeric when compared to sun dried and solar tunnel dried turmeric flakes. Minimum drying time of 10 h was recorded for drying of cured sliced turmeric by oven drying at 100°C and maximum of 165h (6.88 days) was recorded for sun drying of uncured sliced turmeric. Higher values of essential oil, oleoresin and curcumin contents were recorded for uncured sliced turmeric when compared to the cured sliced turmeric. Maximum essential oil content of 5.5% was observed for the uncured sliced turmeric when dried in an oven dryer at 50°C and maximum oleoresin content of 13.07% was obtained for uncured sliced turmeric dried in a hot air oven dryer at 50°C. Curcumin content recorded a maximum value of 5.01% for uncured sliced turmeric when dried at 50°C. Hence, it is concluded that for the production of high quality turmeric, uncured sliced turmeric dried in a mechanical dryer at lower temperatures of 50 to 60°C was better than sun or solar tunnel dried turmeric. Mechanical drying at higher temperatures of 90 and 100°C, drying was much faster than sun or solar tunnel drying, but the quality of final product obtained was considerably lower in terms of both the primary and secondary metabolites.

S3 OP3

Cryogenic grinding: a novel approach to retain quality attributes of ajwain (*Trachyspermum ammi* L.)

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The conventional grinding system involves high energy consumption process and leads to loss of 30% volatile oil content and also loss of colour and odour when temperature rise upto 95% during the process. The conventional grinding system not only provides a product of degraded quality, but also, is not a continuous operation. As during grinding the fat in the spice melts and blocks the grinding surface hindering the continuous flow of grinding operation. The significant reduction in volatile oil content, odour and colour were observed when ajwain was ground by using cryogenic grinding technique. Cryogenic grinding involves grinding operation at very low temperatures (even below -120°C). The cryogenic grinding technique includes pre-cooling of the spice to be ground with cryogenics such as liquid nitrogen or liquid carbon dioxide. The cryogen also maintains the desired low temperature inside the grinder during grinding while absorbing the heat generated during the grinding operation. The extreme low temperature while grinding freezes the volatile oil and thus aids in their retention in the spice powder. This low temperature also ceases the degradation of other bioactive compounds in the spice which have enormous therapeutic properties. Therefore, the present investigation was envisaged to study the quality characteristics of ajwain seed powder ground under cryogenic as well as ambient conditions. In the study, three ajwain seed varieties were chosen, namely, AA 1, AA 2

and AA 93. All these varieties were ground under cryogenic and ambient conditions at moisture levels ranging from 8% to 20% (db). The results showed that, there was more retention of volatile oil content in case of cryo-ground ajwain seeds. Moreover, there was a significant retention of volatile oil in case of AA 2. The total energy consumption was found significantly lower at cryogenic temperatures and also observed distribution of uniform particle size, fine texture and bright colour product than conventional grinding system. The study, therefore suggests that cryogenic grinding system of ajwain is a novel approach as compared to conventional grinding system at ambient temperatures.

SESSION III



DIGITAL POSTER PRESENTATION

S3 P1

Quality characterization of various value added forms of black pepper (*Piper nigrum* L.)

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The present study was undertaken to characterize the quality and volatile oil constituents of various value added product forms of black pepper (BP). The products like dehydrated green pepper (DGP), freeze dried green pepper (FDGP) freeze dried red pepper (FDRP) and white pepper (WP) were used for the analyses. The processed products were analyzed for its essential oil and piperine content using standard ASTA procedures. The flavour profile of essential oil was done using gas chromatography-mass spectrometry (GC-MS). Quality characterization of various value added products indicated that, essential oil content was highest in BP (4.3%) followed by WP (3.3%) and lowest in FDGP (2%). Piperine was found to be highest in WP (5.8 %) while the FDRP had the lowest value of 3.4%. The GC-MS analysis revealed wide variation in the flavour composition of essential oil from various value added products. β -caryophyllene, the principal sesquiterpenoid, was found to be the highest in BP (36%). FDGP and FDRP and WP had highest amount of limonene (17.5%, 21.2% and 25.7%, respectively) as compared to β -caryophyllene (16.3%, 17.4% and 9.7%, respectively). The sesquiterpene compound bisabolene was not detected in BP but was present in all other products. Similarly, caryophyllene oxide was not detected in WP but present in all other products. Wide variation was observed between monoterpenes and sesquiterpene group of compounds among the samples analyzed.

S3 P2

Effect of mechanical washing and peeling on quality of dry ginger

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A mechanical washer cum peeler for ginger was evaluated for its performance. Experiments on mechanical washing of ginger (variety IISR-Rejatha) were conducted for three varying loads of 5, 10 and 15 kg for 5 varying washing periods of 2, 3, 4, 5 and 6 min and the washed ginger was evaluated for its washing efficiency and bruise index. From the study, it is observed that maximum washing efficiency varied from 98.1% for drum load of 15 kg to 98.68% for drum load of 5 kg for washing time of 6 min. Maximum peeling efficiency was obtained when peeling time was 10 min for all the three drum loads evaluated. It was found to vary from 58.1% for drum load of 5 kg to 62.6% for drum load of 15 kg. Drying of washed and peeled ginger was done in a solar tunnel dryer and minimum drying time of 148 h was obtained when ginger was mechanically peeled for 10 min and when the drum load was 15 kg. The washing efficiency of 98.68% could be obtained when ginger was washed for 6 min duration at drum load of 15 kg and the bruise index observed was 17.50 and the capacity of the mechanical washer was found to be 128 kg/h. Peeling of ginger was done in the same mechanical peeler and was found effective when both the inner shaft and the outer drum rotated in the opposite direction at variable speed of 151 rpm and 27

rpm, respectively. Maximum peeling efficiency of 62.60% was obtained when fresh ginger was peeled for 10 min duration at drum load of 15 kg. The retention of essential oil and oleoresin content in dry ginger for the above condition was 1.67 and 4.13%, respectively.

S3 P3

Ginger as a functional ingredient in development of jackfruit ready to serve beverages

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The present study aimed to develop ginger blended jackfruit ready to serve functional beverages with consumer acceptability. Jackfruit ready to serve (RTS) functional beverage was prepared by blending jackfruit pulp (15%) with ginger extract at 0.5, 1 and 1.5% concentrations. The blended combinations of jackfruit beverages as well as control (without ginger extract) were analyzed for biochemical and sensory qualities to find out the best blended beverage formulation. The Kruskal Wallis test for sensory scores revealed significant difference among the treatment combinations for sensory attributes. The jackfruit-ginger functional beverage with 15% jackfruit pulp blended with 1.5% ginger recorded the highest sensory mean scores for taste, flavour and overall acceptability. This combination of jackfruit functional beverage recorded a TSS of 15°Brix, 0.21% acidity, reducing sugar content of 7.14%, 15.04% total sugar with 19.78 mg 100g⁻¹ ascorbic acid, 21 µg 100g⁻¹ carotenoids with an antioxidant activity of 73.68% as DPPH radical scavenging activity, 14.64 mg QE 100g⁻¹ flavonoids and 607.55 mg GAE 100g⁻¹ total phenol content providing health benefits.

S3 P4

Screening ginger (*Zingiber officinale* Rosc.) genotypes for product development

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An experiment was taken up for evaluating ten ginger somaclones and a released variety 'Aswathy' to identify promising genotypes for different end uses. Screening for value added products revealed the suitability of these ginger genotypes for preparation of ginger candy and ginger flakes based on physical and biochemical parameters of the products such as moisture content, colour, total soluble solids, titratable acidity, pH and sensory evaluation. The somaclones viz., SE 8683, C 8626 and SE 8642 were better for candy preparation and SE 8683, C8626, SE8642 and C 8632 were found to be the best among somaclones for ginger flakes because these somaclones recorded higher scores for overall consumer acceptability, storage stability and showed insignificant variation in physico-chemical parameters and scanty microbial load during the storage period.

S3 P5

Effect of drying methods on nutritional composition of coriander (*Coriandrum sativum* L.) leaves

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In the present study, blanched and unblanched coriander leaves were dried with three different drying methods *viz.* shade, solar and cabinet drier. To improve the colour and shelf life, coriander leaves were subjected to blanching by steam boiling for 3-5 minutes. The scores for colour (8.1) and flavour (7.9) were slightly higher in blanched shade dried coriander leaf powder followed by blanched cabinet dried coriander leaves powder. Blanched shade dried coriander leaves powder was registered higher amount of crude fibre (7.31%), fat (0.94%) and ash content (16.47%). Highest amount of β -carotene (35.56%) and ascorbic acid content (132.35%) was found in blanched shade dried coriander leaf powder. Polyphenol content of coriander leaf powder prepared using different drying methods was almost similar. Blanched cabinet drier dried leaf powder contained the highest quantity of protein (7.82 g 100 g⁻¹) which was on par with blanched shade dried coriander leaf powder (6.36 g 100 g⁻¹). Total calcium (179 mg g⁻¹), iron (20.54 mg g⁻¹) and copper content (1.63 mg g⁻¹) were highest in blanched shade dried coriander leaf powder.

S3 P6

Effect of garlic spice oil as an additive on the performance of rice bran oil during deep fat frying

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In the present study, essential oil from garlic was extracted by steam distillation and the standardization of process was carried out. The physio-chemical analysis of the rice bran oil was carried out after addition of garlic essential subsequently followed by FTIR analysis. Parameters such as peroxide value, free fatty acid content, oryzanol content of rice bran oil were analyzed. The result showed higher state of degradation for control sample compared to the blended sample during deep fat frying. FTIR analysis confirmed the results as there was higher transmittance in case of pure rice bran oil depicting a slightly higher level of degradation compared to the blended one.

S3 P7

Antimicrobial properties of some common Indian spicesMinakshi De* & Amit Krishna De¹

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In the present study, about 42 botanically identified species of spices were tested for the

detection of anti-microbial substances against the test organisms viz., *Bacillus subtilis*, *Escherichia coli* and *Saccharomyces cerevisiae*. Of all the spice samples, 26 were found to contain antimicrobial principles active against the above test organisms. These were cumin, cinnamon, black cumin, clove, onion, ajowain, chilli, garlic, celery, basil, tejpat, nutmeg, small cardamom, caraway, turmeric, tamarind, aniseed, black pepper, horse raddish, pomegranate seeds, cambodge, mustard, rosemary, thyme, oregano and star anise. Among these, three spices viz., ajowain, cumin and star anise were studied in detail and were found to have potent antimicrobial compounds. The active compounds were identified and isolated.

S3 P8

Studies on standardization of protocol for herbal tea prepared from leaves of tulsi, drumstick with green tea

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The present investigation was carried out with an objective to study the effect of different blends of tulsi and drumstick leaf powder with green tea and different packaging materials on quality and shelf life of the herbal tea. Leaves of tulsi and drumstick were tray dried, powdered and blended with green teain different ratios to form total eight blends, which were packed in LDPE 200 gauge pouch, aluminium pouch and PET bottles and stored for 90 days. Among the different blends, the herbal tea blend with 70% tulsi leaf + 10% drumstick leaf + 20% green tea powder was the best for retaining reducing sugars, antioxidant content. Whereas, herbal tea blended with 10% tulsi leaf + 70% drumstick leaf + 20% green tea powder was found to be superior in terms of retention of total sugars, non-reducing sugars, protein, ascorbic acid, chlorophyll and low acidity. The blend 100% green tea showed the least amount of moisture and water activity along with retaining high dry matter and phenol throughout the storage period. With respect to packaging materials, herbal tea packed in PET bottle was found to be superior in terms of retention of all the quality parameters. In conclusion, the herbal tea blended with 10% tulsi leaf + 70% drumstick leaf + 20% green tea powder was found to be best in terms of nutritional quality and shelf life.

S3 P9

Effect of postharvest application of enhanced freshness formulation (EFF) to extend the shelf-life and quality of curry leaves (*Murraya koenigii*) var. Senkambu

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Hexanal is an aldehyde, produced during the termination phase of fat oxidation in plant

materials, known to extend shelf life of many horticultural commodities. The study was conducted to extend the shelf life of curry leaf var. Senkambu through postharvest application of Enhanced Freshness Formulation (EFF). The treatments included EFF at three different concentrations *viz.*, 1% (T1), 2% (T2), 3% (T3), water dip (T4) and control (T5 without treatment). Curry leaves were treated with EFF for 2 minutes and the treated produce were air-dried. Treated and untreated samples were stored under ambient condition ($28^{\circ}\text{C} \pm 2^{\circ}\text{C}$, RH $60 \pm 10\%$) and cold room condition ($13^{\circ}\text{C} \pm 2^{\circ}\text{C}$, RH $90 \pm 5\%$). In cold storage, the study was carried out with leaves covered using polythene cover (100 gauge thickness) and without covering the leaves. Shelf life of curry leaf var. Senkambu was six days under cold storage @ $13 \pm 2^{\circ}\text{C}$ when it was treated with EFF @ two and three per cent. However, the weight loss, during the storage period was minimum. Under ambient storage the curry leaves treated with EFF @ 2% recorded minimum PLW of 8.90 and 15.60 per cent on 2nd and 3rd day after storage which was on par with T1 and T3 (EFF @ 1% and 3%) on 2nd 3rd days after storage. Under cold storage the same treatment (T2) recorded 1.43, 1.98, 2.85, 3.96 and 4.27 per cent weight loss during the storage period when the leaves were covered with PE @ 100 gauge thickness. In cold storage, both treated and untreated curry leaves were covered in with polythene cover (100 gauge thickness) recorded minimum weight loss for the entire storage period. Among the treatment, T3 (EFF@ 3%) recorded minimum PLW of 1.32 per cent on 6th DAS however it was on par with T1, T2 and T4 (EFF @ 1, 2% and water dip). There were no significant differences among the treatments for total chlorophyll content of the leaves. It ranged from 0.48 in control (T5) to 0.60 in T1 (EFF at 1%) and total Fe content of the leaves was ranged from 30.22 in T1 (EFF @ 1%) to 39.61 in control (T5) under ambient condition. Total chlorophyll content of the leaves ranged from 0.17 mg/100 g in T5 (control) to 0.29 mg/100 g in T3 (EFF @ 3%) under cold storage with covering of leaves. Whereas, without covering T4 (water dip) and T5 (control) showed that the maximum chlorophyll content (0.63 and 0.51 mg/100 g respectively). Significant differences were observed for total iron content of the leaves which ranged from 30.22 mg/100 g of leaves in T1 (EFF at 1%) to 39.61 mg/100 g in T5 (control) under ambient storage. While in cold storage, total Fe content was maximum in T5 (control) with 39.85 mg/100 g followed by 37.34 mg/100 g in T4 (water dip). Besides, total colour difference was minimum ($\Delta E = -2.77$ & 0.81) in leaves were treated with EFF at three and two per cent under ambient storage whereas, T1 (EFF @ 1%) treated leaves showed less total colour difference ($\Delta E = -1.91$) under cold storage condition.

SESSION IV



**Spices – Cutting edge technologies
for plant health**

ORAL PRESENTATION

S4 OP1

Molecular, metabolome and endophyte analysis of *Zingiber zerumbet*: en route to decipher resistance towards necrotrophic *Pythium myriotylum*

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Ginger is susceptible to soft rot disease, caused by soil-borne pathogen, *Pythium myriotylum*. There are no registered fungicides for use against *Pythium* spp. and current disease management strategies rely on use of fungicides, Mancozeb and Metalaxyl, unmindful of the collateral damage they pose to environment and human health. Being taxonomically distinct from fungal phytopathogens, disease management of *Pythium* spp. requires different chemistries than the one used against fungi. Furthermore, unlike foliar pathogens for which resistance is generally encoded in plant genome, factors contributing to resistance against soil-borne pathogens are complex. With no doubt, plant resistance can be ascribed to a number of responses induced upon pathogen perception. Wild plants are usually well adapted to extreme conditions and resist pathogen infection due to the extra ordinary metabolite profile and/or presence of novel genes/pathways. *Zingiber zerumbet*, a wild congener of ginger exhibits remarkable biotic resistance and is widely cultivated in the tropical countries for its medicinal properties. *Z. zerumbet* has been reported to have a rich repertoire of diverse secondary metabolites (SM). Being rich in terpenoids and phenylpropanoidpolyketides, a significant part of the chemical diversity in *Z. zerumbet* could be expected to protect the plant from invading phytopathogens. In *Z. zerumbet*, the composition of the principle metabolite viz., the C15 sesquiterpene ketone namely zerumbone varies from 12.6-73.1% according to geographic locations. Systemic induction of the sesquiterpenoid, zerumbone was observed in the wild taxon which was validated by metabolomic data generated following *P. myriotylum* infection. The results divulged the significant role of the principal sesquiterpenoid viz., zerumbone in *Z. zerumbet* resistance mechanism. Plant defense strategies being dynamic, it is proposed that in *Z. zerumbet*-*P. myriotylum* pathosystem, a single metabolite or class of metabolites does not comprise the only defense mechanism. Rather concomitant action of various metabolites/molecules in *Z. zerumbet* contributes to the continuous chemical warfare against the soil-borne pathogen. In this direction, upregulation of phenylpropanoid pathway towards curcuminoid biosynthesis was observed in *Z. zerumbet*, thus constituting an additional inducible chemical defense strategy employed together with sesquiterpenoid-based defenses. With phenolics and terpenoids being carbon-based, it is unlikely that both phenolics and terpenoids would be deployed to high levels during defense as it will be a considerably costly trade-off. Additional insights were elucidated with respect to induction of antimicrobial peptides (AMP) following *P. myriotylum* infection in *Z. zerumbet*. Besides the host plant metabolites/molecules, emergent properties during complex pathogenic interactions could also be accounted to the plant microbiome. With variations observed in composition of plant microbiome across different plant taxa, a comprehensive approach to bioprospect microbes from *Z. zerumbet* studies that offer competitive advantage to the host plant was determined. The studies have revealed important insight into the concomitant action of various molecules in imparting resistance against the soil-borne necrotrophic oomycete.

S4 OP2

Responses of signaling marker genes against bacterial wilt in resistant and susceptible ginger among different tissues

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Ginger is susceptible to *Ralstonia solanacearum* infection which causes bacterial wilt in the plants. Here the expression of marker genes of various signaling pathways such as salicylic acid, ethylene and jasmonic acid in susceptible (ginger, *Zingiber officinale*) and resistant (mango ginger, *Curcuma amada*) species after inoculation with *R. solanacearum* were compared using quantitative real-time PCR. The results showed that, all the three signaling pathways were activated in both ginger and mango ginger during infection. When expression was compared with susceptible and resistant gingers, marker genes of jasmonic acid such as allene oxide cyclase (AOC) and lipoxygenase (LOX) did not show significantly different ($p < 0.05$) expression in most of the time intervals studied. In contrast, the salicylic acid pathway marker genes such as non-expressor of PR1 genes (NPR1) and TGACG sequence-specific binding protein (TGA6) and the ethylene pathway marker genes, such as AP2 domain class transcription factor (AP2) and 4-Coumarate: CoA ligase (4CL1), were expressed with a statistically different ($p < 0.05$) fold change among gingers at all the time intervals. These results indicated that, even though jasmonic acid was activated upon infection, salicylic acid and ethylene signaling pathways play an important role in giving resistance in mango ginger. Moreover, the time and magnitude of expression plays a higher impact in host pathogen resistance.

S4 OP3

Application of artificial intelligence and machine learning techniques for varietal selection in turmericS Varadha Raj^{1*}, R Chitra¹, Suresh Babu² & K R Ashok³¹Horticultural College & Research Institute, Tamil Nadu Agricultural University, Periyakulam-625604, Tamil Nadu, India²International Food Policy Research Institute, Washington DC, USA³Centre for Agricultural & Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore-641003, Coimbatore, Tamil Nadu, India

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The value of turmeric is decided based on the content of curcumin, essential oil and oleoresin. The curcumin content decides the level of utility and value in pharmaceutical industries. Generally, the curcumin content will vary from location to location in the same variety and different cultivars. The turmeric variety Pratibha has the highest curcumin content of 6.21% in Kerala, whereas it is 2.87% and 1.28% in Coimbatore and Salem districts of Tamil Nadu, respectively due to varying edaphic and climate factors. Identification of genetically superior turmeric with high curcumin content is not possible by simple chemotyping method. It is largely influenced by several edaphic factors like pH, NPK and organic carbon and environmental factors such as temperature, rainfall, and relative humidity. Identification of the needy varieties and prediction of varietal classification through artificial intelligence and machine learning (AI and ML) techniques is warranted in modern

horticulture. This paper attempts to explore the utilities of AI and ML in varietal selection. The data on length and diameter of rhizome and primary finger from major four varieties; Roma, Salem local, Swarna and Erode local were collected from 150 sample respondents in Erode district. The support vector machine (SVM) and artificial neural network (ANN) techniques were used to predict the varietal selection in turmeric using R software. The SVM type of C-classification and number of support vectors of 109 and number of classes of four *viz.*, Erode local, Roma, Salem local and Swarna were used in the model building. 90 per cent of the data set was taken as a training set. Out of 150 samples, the diagonal value of each class represents a perfect fit. Erode local had the highest diagonal value of 9, followed by Swarna (5), Roma (3) and Salem local (1). The 10 layers of ANN with softmax, the algorithm was developed and responded to our specific attributes, machine to give a solution. In the experimental validation of the model, if 4 cm of rhizome length, 5 cm of rhizome diameter, 3 cm of finger length and 2 cm of finger diameter are needed attributes of the farmer and the machine could give the output of Erode local as choice variety. In future, the curcumin content-based prediction model for turmeric can also be developed with edaphic and environmental factors using ANN.

S4 OP4

Influence of PGRs on growth and yield of saffron (*Crocus sativus* L.)

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An investigation was undertaken to analyze the effect of plant growth regulators *viz.*, naphthalene acetic acid (NAA), gibberellic acid (GA) and chlormequat (CCC) on growth and yield of saffron. The experiment was laid out in a randomized block design with three replications at Research Farm of Advanced Research Station for Saffron and Seed Spices, SKUAST-Kashmir during 2018-2019. The corms were treated with 5 different concentrations each of NAA (100, 200, 400, 600 and 1500 ppm), GA₃ (50, 100, 200, 300 and 400 ppm) and CCC (400, 600, 800, 1000 and 1200 ppm) to determine whether these treatments have any statistically meaningful effects on growth and yield of saffron. Irrespective of the level, application of GA₃ to corms markedly increased yield and yield attributes compared to NAA, CCC and untreated control. Plant height (cm), number of leaves/corm, fresh and dry weights of herbs, number of flowers/corm, stigma length (cm), fresh and dry weight (mg) of stigmas and stigma yield (mg/m²) was appreciably higher in GA₃ treated corms. Application of GA₃ 50 ppm was at par with GA₃ 100 ppm and CCC 400 ppm significantly increased number of flowers/corm, stigma length (cm), fresh and dry weight (mg) and yield (mg/m²) over other treatments, while the lowest values of these traits were recorded with the treatments *i.e.* GA₃ 400 ppm, CCC 1000 and 1200 ppm. Similarly, NAA treatment @ 100 ppm significantly increased the plant height, fresh and dry weights of herbs and number of leaves/corm. Corms treated with higher doses of NAA failed to produce flowers although a greater number of buds sprouted in these corms which was presumably due to release of apical dominance. In general, the frequencies of the different plant growth regulators with regard to the improvement in yield and yield attributes were found in the following order GA₃>CCC>NAA, while with regard to growth parameters a different order was noticed NAA>GA₃>CCC.

S4 OP5

Micronutrients improve more of quality than yield of nigella desicred from various modes of their application

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The present study was carried out with three modes of micronutrient application i.e. seed priming (Fe_{500} , Zn_{500} , Mn_{500} , Cu_{500} and B_{250} ppm), soil application (Fe_{10} , Zn_5 , Mn_{10} , Cu_5 and B_5 kg ha⁻¹) and foliar spray ($\text{Fe}_{0.05}$, $\text{Zn}_{0.05}$, $\text{Mn}_{0.05}$, $\text{Cu}_{0.05}$ and $\text{B}_{0.02}$ % of their salts) and the results were compared to the control plots. The results revealed that, highest plant height was found with soil application and seed primed by zinc. However, all the growth parameters were improved by foliar application of micronutrients. Seed filling and density of seeds were improved by soil application of boron and iron, seed priming by copper and foliar application of zinc. Crop responded well to iron, zinc and manganese applied in soil with respect to seed yield, whereas seed priming was most effective with iron, zinc and copper. All the five micronutrients were found effective when applied through foliar spray for the enhancement of seed yield. Mean value of all the three modes of micronutrient application indicated that, highest seed yield obtained with foliar application of these nutrients followed by soil application, however yield was least when these elements were used for seed priming. Dry stover accumulation was highest by soil application of iron and zinc, whereas it was only higher with manganese used for seed priming. In case of foliar application, stover accumulation was enhanced by all the micronutrient elements except zinc. In general, oil content was more with all the micronutrient and their modes of applications, however oil content was highest with soil application of copper, seed priming and foliar spray of iron. Overall effect of micronutrients on oil content was highest in soil application followed by foliar application and was least with seed priming. Correspondingly, oil yield was also more with all the micronutrients and their modes of their application except boron in soil. For higher oil yield of nigella, copper played a crucial role when applied in soil, iron in seed priming and boron in foliar application. Hence it can be concluded that, foliar application of micronutrient under Typic Haplustepts soil is more desirable than any other mode for higher yield and quality of nigella followed by soil application. Copper application in soil enhanced the seed yield per cent by 14.6 as compared to control, however quality was improved by 21.3%. Likewise, seed primed with iron yielded 25.4% more than control, whereas quality went up for 34.5% over the control.

S4 OP6

New insights on microbiome assisted crop protection and management

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Naturally occurring plant associated microorganisms, also termed as plant microbiome, are ubiquitous, and are known to colonize diverse habitats in and on plants. Plant microbiome can be described as the sum total of the genomic contribution made by the diverse microbial communities that inhabit plant-niches like spermosphere, phyllosphere,

endosphere, and rhizosphere. Healthy plant *per se* in natural environment is now considered as microbiome phenotype or microbiome associated phenotype. It is also speculated that the microbiome components can offer novel and yet to be discovered Microbe Associated Molecular Pattern (MAMPs) with a potential to confer broad spectrum immunity against plant pathogens. Novel MAMPs can lead to identification of plant receptors (MAMP recognition receptors) playing roles in plant defense against biotic stress. Advancement of “Omics” technologies has contributed significantly in understanding the plant microbiota and their ecological functions. The complex intra-microbial interactions as well as their phytosphere interactions are likely to impact plants performance. The plant microbiome investigations offers exciting opportunities to explore competing and cooperating microbiota that would culminate in identification of microbiome-components with crop management capabilities for NexGen agriculture and horticulture. Microbiome assisted crop protection is gaining acceptance world-wide due to its ability to restore microbial diversity in modern crop production systems where large-scale cultivation of narrow genetic stocks of crops in industrial scale production has created biological and microbiological-homogeneity. Here, the role of microbiome restoration by deliberate microbiome transplantation on specific plant niches assumes significance for sustainable crop production. Experiences gained from in-depth investigations on phyllosphere and endosphere microbiome using polyphasic microbiome tools including next generation sequencing (NGS) technologies will be discussed alongside strategies for microbiome assisted spice production.

SESSION IV



DIGITAL POSTER PRESENTATION

S4 P1

Analysis of LRR receptor kinase gene of *Phytophthora capsici* causing foot rot disease in black pepper

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Phytophthora is one of the most destructive pathogens of several economically important crops and in black pepper it causes foot rot disease which is identified as major production constraint. *P. capsici* is a polycyclic pathogen and can cause infection by several means such as sporangia, zoospores, oospores and chlamydospores. A large set of genes have been identified that express specifically at different asexual stages (mycelium, zoospores and germinating cyst) and infection stages of *P. capsici*. Leucine-Rich Repeats-Receptor Kinase (LRR-RKs) plays a role in asexual development and pathogenesis of the oomycete pathogens. Recently, the role of PcLRR-RK1 gene in pathogen growth, sporangial formation and development and zoospore production has been demonstrated. PcLRR-RK1 was also shown to be required for germination of cysts and growth of germ tubes that are essential for disease initiation of *P. capsici* zoospores. In the present study, a LRR-RK gene was amplified from *P. capsici* isolated from black pepper, cloned and sequenced. The gene was approximately 2.2 kb in size and the nucleotide sequence of LRR-RK gene shared 98.4% identity with *P. capsici* isolate LT1534 from JGI genome portal and 35.9 to 74.6% identities to *P. sojae* hypothetical protein, *P. parasitica* TKL protein kinase and *P. infestans* protein kinase from NCBI. The expression of LRR-RK gene during different stages of infection in black pepper was studied using qPCR assay. QPCR analysis was carried out with samples collected at 2, 4, 6, 24, 48 and 72 hrs after inoculation and found that the expression of LRR-RK gene was high at 24 hrs after inoculation. The gene was also found to express during sporulation. The results of the study show that LRR-RK is expressed during *P. capsici* infection in black pepper and further detailed studies are required for its utilization in early detection and management of *P. capsici* infection.

S4 P2

Effect of biological agents on root knot nematode, *Meloidogyne incognita* in black pepper (*Piper nigrum*)

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A nursery experiment was conducted to evaluate the efficacy of different biological agents such as *Paecilomyces lilacinus*, *Pochonia chlamydosporia* and AM fungi on root knot nematode management in black pepper. The study revealed that all the biological agents were found to have potential to increase significant plant growth in terms of number of leaves and plant biomass. The maximum number of leaf per plant was recorded in *P. chlamydosporia* treated plants which was significantly different from untreated control followed by AM fungi and *P. lilacinus*. The maximum plant biomass (46%) was recorded in *P. chlamydosporia* and it was on par with AM fungi. The root knot nematode *M. incognita* alone recorded least bio mass of 21 g. The population of root knot nematode *M. incognita* in soil and roots

were significantly lower in all biological agents treated cuttings than untreated control. Nematode population in soil, egg mass/g and adult female nematode/g was significantly reduced in *P. chlamydosporia* treated plants when compared to untreated control.

S4 P3

Effect of different potting media on sprouting, survival and growth of bush pepper (*Piper nigrum* L.)

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The present investigation was conducted at Experimental farm, Department of Horticulture, College of Agriculture Dr. B. S. K. K. V. Dapoli, Dist. Ratnagiri during the year 2018-2019. The experiment was executed in randomized block design with thirteen treatments and two replications. In different potting media, the highest sprouting percentage (40.0%) and survival, percentage (24.0%) was observed in T₁₀ i.e. soil + rice husk + compost (1:1:1). Maximum number of leaves were recorded in treatment T₉ (7.85) i.e. soil + rice husk + compost (2:1:1) and highest plant height was observed in treatment T₁₀ (35.81 cm). The bush pepper cuttings were ready for planting at the age of nine months.

S4 P4

Genetic variability for morpho physiological traits in elite black pepper accessions

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Black pepper is the most commonly used spice, throughout the world and its extracts have been used in folk medicine. It is a perennial woody evergreen climbing vine, native to evergreen forests of the Western Ghats of South India and is extensively cultivated in tropical regions. Plant requires a long rainy season, fairly high temperature and partial shade for its best growth. By opening and closing of stomata, plants can regulate the amount of water loss, when the environmental conditions are unfavorable. Drought stress modifies the physiological parameters such as stomatal count and wax. Ultimately, it destabilizes the membrane structure and permeability, protein structure and function. Here we have studied the genetic variability for morphology (leaf length, leaf width, petiole length and internodal length), stomatal density and wax content of 40 black pepper genotypes identified for their drought tolerance in preliminary screening. The study was carried out in ICAR-IISR Experimental Farm, Peruvannamuzhi. The experiment was laid out in RBD with four replications. The data analysis revealed a significant genetic variability among these accessions for morphological characters, stomatal count and epicuticular wax. The leaf area ranged from 99.37 cm² to 29.36 cm² and highest value was observed in the accession 1083. Accession 6720 had the maximum wax content (25.96 µg/cm²) and the accession 1218 showed the minimum value (0.38 µg/cm²). Stomatal density ranged from 94 (accession 1086) to 41 (accession 1368) per 20X microscopic field.

S4 P5

Influence of anti transpirants on black pepper gas exchange parameters and yield during summer season

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The experiment was conducted in farmer field for three years with an aim to reduce effect of light and moisture stress on black pepper in summer season. Anti-transpirants such as Kaolin 2%, Kaolin 2% + 0.5 % MOP, spray lime 1.5%, Spray lime 1.5% + 0.5% MOP, Miracle 3ml/litre were sprayed on black pepper in farmer field in Sukarvarsanthe. Physiological parameters like photosynthetic gas exchange parameters, canopy temperature, chlorophyll fluorescence and yield characters were recorded. From this result, lime 1.5% showed higher photosynthetic rate while maintaining lower leaf temperature.

S4 P6

Mutagenic effect of gamma rays in black pepper cuttings

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The present investigation was undertaken by exposing the stem cuttings (3 cm length) of black pepper (Panniyur-1 hybrid) to gamma irradiation of various doses (10, 20, 30, 40, 50, 60, 70 and 80Gy) along with untreated control in order to standardize the dosage of gamma rays for induction of mutation in black pepper. The observations were made on sprouting behaviour, length of sprout, dimensions of leaf, other leaf characters like leaf shape, leaf margin and chlorophyll mutation (albino/xantha) along with the survival ability of sprouted cuttings. The sprouting of cuttings was found better till 60Gy of gamma radiation and lower percentage of sprouting of cuttings in 70 and 80 Gy of gamma irradiation up to 8 months of planting. The occurrence of major viable mutants from in rooted cuttings *viz.*, trifoliate leaves, bi-forked leaves, malformed leaves, uneven leaves, *etc.*, which were found in the treated cuttings other than the characters mentioned in the descriptor. An increased dimension of leaves was found in cuttings treated with 10 Gy of gamma rays. However, the survival of cuttings, more number of branches and leaves, variations in leaves, formation of albino type of leaves were found higher in cuttings irradiated with 50 Gy of gamma radiation. Further study is on to isolate effective mutants and their evaluation for quality and yield characters.

S4 P7

Pericarp as a new berry trait to define spike yield in black pepper (*Piper nigrum* L.)M S Shivakumar*, S Aarthi¹, H J Akshitha, K S Krishnamurthy¹, K V Saji¹ & B Sasikummar¹

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Eighteen black pepper (*Piper nigrum* L.) genotypes consisting of varieties/hybrids and land races/farmers varieties were investigated using ANOVA, correlation, path analysis, Scott-Knott test and Principal Component Analysis (PCA) to ascertain the contribution of the berry components on spike yield. The results revealed that all the 15 traits under investigation were statistically significant among genotypes. Traits like spike length, number of mature berries/spike, dry seed weight, fresh seed weight and berry weight showed high positive correlation (>0.8) with spike weight. Path analysis confirmed that berry weight and seed size are contributing directly to spike weight. Grouping of genotypes based on Scott-Knott test revealed Panniyur-1 and Nedumchola as contrasting genotypes for maximum number of traits. IISR Malabar Excel and Agali genotypes were highly contrasting for pericarp to seed size ratio. Likewise, Nedumchola and IISR Malabar Excel, Jeerakamundi and IISR Thevam were contrasting for dry to fresh pericarp weight ratio and dry to fresh seed weight ratio, respectively. Based on PCA, the first three components explained over 88 % of total variation. Among three PCs, first PC accounted for 42.4% of variation with fresh berry weight, dry seed weight and fresh pericarp weight being the major contributors. Hitherto the pericarp weight has not been considered as selection criteria in black pepper breeding, though the other two had been accounted for. Biochemical analysis revealed that intrinsic quality components like piperine, oleoresin and starch were more in seed than pericarp. Protein, phenols and reducing sugars were higher in pericarp than seed suggesting that genotypes with thin pericarp and large seed size should be targeted for quality improvement in black pepper.

S4 P8

Propagation studies in Woody Pepper (*Piper pendulispicum* C. DC)

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Woody pepper is a wild relative of black pepper found distributed in the Andaman Islands in the Bay of Bengal. Fresh stem pieces of this species are sold in local markets and are utilized as spice. The produce is getting rates of Rs. 300-1,000/- per kg in the local markets depending on thickness of the stems harvested. Considering the commercial value of this underutilized genetic resource, systematic studies were initiated to facilitate its domestication process. For area expansion of this novel spice, availability of the quality planting material is a major issue. In first experiment, performance of two node cuttings from runner shoots and serpentine method of propagation was compared. Results revealed that establishment of stem cuttings was very poor (20%) when compared with serpentine method (98%). To improve the multiplication rate and establishment of the propagules, further studies were taken up. A new method called Radial Serpentine Method was

developed, which had advantage of better multiplication rate. Mean multiplication of 164.0 propagules per mother plant were obtained from this new method over 26.6 propagules per mother plant in serpentine method. Establishment of propagules in both the cases was comparable. Considering this, woody pepper could be efficiently multiplied through radial serpentine method. This will help in rapid multiplication of the species, even at farmers' fields, to facilitate area expansion of this novel spice in the Andaman Islands.

S4 P9

Screening for disease resistance in black pepper against mixed virus infection by *Cucumber mosaic virus* and *Piper yellow mottle virus* (PYMoV)

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In Kerala Black pepper is reported to be affected by two major viral diseases viz. stunted disease /mosaic / little leaf caused by a strain of *Cucumber mosaic virus* (CMV) and *Piper yellow mottle virus* (PYMoV) caused by a strain of *Badnavirus*. A detailed survey was carried out in the major pepper growing tracts of Thiruvananthapuram and Kollam districts to study the occurrence and spread of the disease and the results showed that the virus disease was widely prevalent in these two districts, even though the per cent disease incidence and severity varied from locality to locality. The severity of the disease in black pepper was also estimated by preparing a disease severity chart. The reaction of different pepper varieties to the virus disease was also evaluated in the survey. Screening for the source of resistance in different black pepper cultivar was also conducted under insect proof glass house condition. The varietal screening was performed based on the vulnerability index (VI). The healthy plants of 12 pepper varieties were graft inoculated with diseased scion from black pepper cv. Karimunda for the development of symptom expression. Based on VI, cultivars were grouped into four categories based on their comparative tolerance to virus infection. Among the other varieties screened Panniyur-2, Panniyur-3 and Panniyur-4 were found to be moderately resistant and that of P5, 6 and 7, Malabar Excel and Shakthi were moderately susceptible. Kuthiravallypadappan and Kottanadan were susceptible. In the field conditions a variety with low vulnerability index may show high vulnerability index in artificial screening. The difference of VI can be attributed to non-uniformity of virus inoculum under natural conditions. Hence artificial screening of varieties may be useful in successful identification of source of resistance. Native PAGE was also carried out for analysing the isozyme profile of defense related enzymes, peroxidase and polyphenoloxidase. The results showed that there was significant difference in isozyme production (both in number of bands as well as intensity of production) between healthy as well as virus infected black pepper plants of Karimunda and moderately susceptible varieties, Panniyur4 and Panniyur 5. The difference in the isozyme banding pattern is an indication of level of resistance of the mentioned varieties. Therefore different isoform bands of specific electrophoretic mobilities are coded by different alleles or separate genetic loci and indicate the level of resistance. The difference in isozyme pattern in healthy and virus infected plants could also be used for the detection of virus in the symptomless infected plants as the masking of symptoms was noticed during unfavourable weather conditions. This study will also help the plant breeders in their breeding programmes.

S4 P10

Studies on effect of grafting on yield and quality of black pepperSourabha V Hegde*, Laxminarayan Hegde, N K Hegde & R Sivaranjani¹

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Foot rot disease caused by *Phytophthora* is one of the major threats in black pepper cultivation. Management of this disease is a major challenge for increasing the income of farmers. Black pepper is commercially propagated through vegetative means by using cuttings (runner shoots or orthotropic shoots). However, grafting is one of the options to manage the foot rot apart from the other control measures. *Piper colubrinum* is found to be resistant rootstock to this disease which is also compatible with *P. nigrum*. In order to control the foot rot disease of black pepper farmers are opting grafted black pepper plants using Brazilian pepper as root-stock for re-establishing the plantations. But, there is meagre information on the yield efficiency and quality of grafted black pepper plants in comparison to that of normally propagated plants (cuttings). A field study on effect of grafting on yield and quality of grafted plants was conducted in a farmer's field at Sirsi during 2017-19. The yield and quality of twenty grafted black pepper vines were compared with twenty vines which were propagated through cuttings. The results revealed that, there was no significant difference in the yield of grafted vines and conventionally propagated vines. It was also observed that there was no significant difference in essential oil yield and piperine content of the vines propagated by either of the ways when biochemical analysis was carried out. However, the oleoresin content was higher in vines propagated through cuttings. Therefore, it can be inferred that, propagation method has less influence on the yield and quality of black pepper. Hence, grafting method of propagation may be efficiently utilized to combat foot rot disease without compromising with yield and quality of black pepper.

S4 P11

Supplementary nutrition improves yield sustainability in fertigated black pepper

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Fertigation is a method of delivery of soluble fertilizers at the root zone of the crops through drip irrigation and farmers have started adopting this precision technology in perennial spice crop like black pepper. But the dosage of fertilizer to be supplied through fertigation is yet to be studied. To confirm whether the fertilizer as per POP supplied through fertigation is sufficient for sustaining yield, an adaptive trial was conducted at Laxmi Estate, Hosahalli, Mudigere. Based on the initial soil and leaf nutrient status and the yield levels (5-8 kg dry/std) the fertilizer dose to be supplemented over and above the dose through soil and leaf were calculated and applied. The treatments were additional nutrient supplementation through soil and foliar applications of NPK and micronutrients as compared to control

(fertilization alone). Fertilization contributed to building up of very high nutrient status of P and Ca in the soil causing imbalance to the nutrient requirement. The requirement of K, Mg and micronutrients like Zn and B were found to be essential based on soil and leaf contents for achieving the targeted yield levels and were supplemented through soil and foliar applications. Application of foliar NPK and micronutrients either alone or in combination increased the leaf concentration of P, K, Mg, Zn and B. Soil supplementation of fertilizers and foliar spray of NPK & micronutrients over and above fertilization recorded significantly higher number of spikes, spike weight, transpiration, photosynthetic rate and carboxylation efficiency. Significantly higher dry yield was recorded in NPK+ micronutrients (5.3 kg/std) followed by micronutrients (4.56 kg/std) supplemented vines with an increase of 28% & 13.6% in yield over fertilization alone. Additional investment of up to Rs. 15.00 per standard over and above fertilization has yielded an additional profit of ₹170.00 - 390 per standard.

S4 P12

Development and evaluation of F1 hybrids of small cardamom

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Hybridization programme on small cardamom was undertaken between the farmer developed varieties such as Njallani Green Gold (MCC-260) and Thiruthali and a released hybrid variety; ICRI-5 at Indian Cardamom Research Institute, Myladumpara, Idukki, Kerala during 2013-14. The hybrid seedlings were raised, planted and evaluated for the consecutive three years (2016-19) in the experimental farm of the Institute in randomized block design (RBD) with three replications and 12 plants per plot, adopting a spacing of 3 m x 3 m during 2014. The trial includes 4 hybrids such as ICRI-5 x ICRI-5, ICRI-5 x MCC-260, Thiruthali x MCC-260 and MCC-260 x Thiruthali. Three years' data on growth and yield attributes were recorded, analyzed and pooled and found that the hybrid (Thiruthali x MCC-260) performed better compared to other hybrid clones with respect to the projected yield (2239.89 kg/ha) followed by MCC-260 x Thiruthali (1892.11 kg/ha). It is observed that plant height was significantly more in Thiruthali x MCC-260 (296.82 cm) followed by MCC-260 x Thiruthali (289.68cm). More tillers were found in ICRI-5 x MCC-260 (50.23cm). Panicles per clump were more in Thiruthali x MCC-260 (58.28). Racemes per panicle were more in ICRI-5 x MCC-260 (24.56) followed by Thiruthali x MCC-260 (23.62). Number of capsules per racemes were more in ICRI-5 x MCC-260 (8.66) followed by Thiruthali x MCC-260 (7.59). These clones will be further evaluated under different multi-location trials to prove its adaptability in different zones of cardamom tracts.

S4 P13

Development of low cost artificial diet for production of entomopathogenic nematode strain ICRI - 18 for ecofriendly management of root grubs in small cardamom

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Root grub (*Basilepta fulvicorne* Jacoby) is a destructive pest of small cardamom and can be effectively controlled eco-friendly and biologically by entomopathogenic nematodes, *Heterorhabditis indica*, a strain ICRI EPN - 18. This strain is mass multiplied using the greater wax moth, *Galleria mellonella* L. which involves high cost for culturing the larvae in the laboratory. So an experiment was conducted to develop the best and cheaper artificial diet composition for maximum mass production of EPN infected *Galleria* cadavers in the laboratory. Among seven different diets tested, low grade milk powder 100g, low grade glycerin 60ml, honey 60ml, corn flour 200g, wheat bran 100g, wheat flour 100g and yeast 20g, produced almost maximum EPN infected *Galleria* cadavers (300 cadavers) which was cheaper and on par with standard diet (milk powder 100g, honey 100ml, glycerin 100ml, corn flour 200g, wheat bran 100g, wheat flour 100g and yeast 50g) (305 cadavers).

S4 P14

Effect of moisture stress on morphological parameters in cardamom (*Elettaria cardamomum* Maton) genotypesSadashiv Nadukeri*, K Umesh, M K Naik, V Srinivasa, S J Ankegowda¹ & L Hanumantharaya

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An experiment on the study on effect of moisture stress on morphological parameters in cardamom genotypes was undertaken at College of Horticulture, Mudigere during 2016-17. This experiment was conducted by planting the suckers in 22 litre capacity plastic pots for set of 67 genotypes of cardamom maintained at Zonal Agricultural and Horticultural Research Station, Mudigere. The result of the present investigation from the ANOVA showed that all the morphological characters showed significant difference at one and five per cent level of probability at before and after imposition of the moisture stress except for the trait number of dried tillers per clump which exhibited non-significant differences under moisture stress condition at 90 days after imposition of the moisture stress. With respect to *per se* performance, maximum tillers height was observed in Green Gold (221.3 cm), maximum pseudostem diameter in HS-1, CL-698 and 26-16-D11 (2.8cm), maximum number of leaves per clump in 26-16-D-11 (97.8), leaf length in M-2 (63.7 cm) and leaf breadth in MCC 200 (10.6 cm) at before imposition of the moisture stress. At 90days after imposition of the moisture stress, maximum tiller height was recorded in Green Gold (190 cm) which was at par with the genotypes CL-73 (189 cm), minimum number of tillers dried per clump was recorded in PV-4, PDP-14, CL-73, D-163, MCC-12, 2-5-D11 and 8-4-

D11 (4.0), maximum pseudostem diameter was recorded in CL-698 and APG-284 (2.1 cm), maximum number of green leaves per clump was observed in HS-1, 26-16-D11 and APG-284 (39), Green Gold manifested maximum leaf length (55 cm), RR-1 put forth maximum leaf breadth (9.93 cm), maximum dry weight of leaves was observed in APG-284 (88.23 g/plant), maximum dry weight of pseudostem was recorded in CL-73 (170.41 g/clump) and maximum total dry matter was recorded in APG-284 (286.2 g).

S4 P15

Evaluation of foliar nutrient application practices in small cardamom under Karnataka conditions

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A field experiment was conducted during 2016-19 at Indian Cardamom Research Institute, Regional Station, Sakleshpur, Karnataka to evaluate the effect of foliar fertilizer application on growth and yield of cardamom (*Elettaria cardamomum* Maton) and work out its economic benefits. The experiment consisted of eight treatments and three replications laid out in Randomized Block Design. The pooled yield data over three years recorded highest yield (194.84 kg ha⁻¹) for the soil application of recommended NPK fertilizers @ 75:75:150 kg ha⁻¹ in two splits along with foliar application of Urea, SSP and MOP (2: 0.5: 1 %). Application of water soluble fertilizer 19:19:19 at the rate of 10 g per litre also recorded on par yield (188.79 kg ha⁻¹) in comparison to recommended NPK fertilizers @ 75:75:150 kg ha⁻¹ and foliar application of Urea, SSP and MOP (2: 0.5: 1 %). The former treatment recorded B: C ratio of 2.38 and 2.56 in latter treatment. The number of bearing tillers per clump was significantly higher for soil cum foliar application among all treatments while no. of panicles per clump and no. of racemes per panicle were significantly higher for both treatments compared to other treatments. However foliar NPK concentration above 4% resulted in phytotoxicity in cardamom (Malabar type) and noted a decreasing trend in yield. A separate pot culture experiment was conducted in growth chamber to study the effect of foliar application of nutrients and found that higher root biomass was recorded in cardamom plants with the application of nutrients by soil cum foliar method. The study points to the need for judicious application of fertilizers in soil and supplement with foliar nutrition for sustainable yield in cardamom under Karnataka conditions.

S4 P16

Field evaluation of F1 hybrids of small cardamom (*Elettaria cardamomum* Maton)

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In order to identify the most suitable hybrids under high ranges of Karnataka, Hassan District, a trial was laid out in the Experimental Farm of the Indian Cardamom Research Institute (ICRI) at Sakleshpur, Karnataka in randomized block design (RBD) with three replications and 12 plants per plot, adopting a spacing of 3m x 3m during 2014 - 2019. Ten

F1 hybrids were included in the trial with one check ICRI 8. Cardamom being a commercial crop, more attention was paid for yield evaluation. Three years pooled data showed that the promising hybrid SHC 28 (SKP 189 x MCC 260) found the best genotype with the yield of 1255 kg ha⁻¹ followed by 1077 kg ha⁻¹ in SHC 24 (SKP 189 X SKP 184). Significantly more tillers were found in SHC 28 (34.1). Bearing tillers were significantly more in SHC 28 (19.3). Panicles were also significantly more in SHC 28 (32.1) followed by SHC 24 (30.0). Racemes were significantly more in SHC 28 (26.8) followed by SHC 24 (26.8). Capsules/raceme were significantly more in SHC 28 (6.4) followed by SHC 24 (5.4). Among the ten hybrids evaluated, SHC 28 and SHC 24 found good for Karnataka region. These two clones can be further evaluated under different regions of Karnataka.

S4 P17

Influence of different irrigation and fertilizer dose on capsule yield of small cardamom

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Limited use of water and nutrients in cardamom cultivation is important for sustainable crop production. Hence the investigation was carried out on standardization of quantity of irrigation and nutrients for better capsule yield of cardamom. Field experiment was conducted during 2014-15, 2015-16 and 2016-17 in ZAHRS, Mudigere in Karnataka. The experiment consists of four main plot treatments (Irrigation levels) and four sub-plot treatments (fertilizer levels) with three replications. The variety, M-1 was used in the experiment with spacing of 1.8 x 1.8 m. The pooled result revealed that irrigation level 9 L/day/clump along with 100 per cent Recommended Dose of Fertilizer (RDF) gave higher average capsule yield (316.16 kg/ha) which was on par with irrigation level 9 L/day/clump along with 75 per cent RDF (307.37 kg/ha). These treatments were significantly superior over the conventional method of irrigation and nutrition (263.13 kg/ha). The treatments, 9 L/day/clump with 75 per cent and 100 per cent RDF showed higher Cost: Benefit ratio 1:3.53 and 1:3.37 respectively. These treatments were significantly superior over conventional method (1:2.76). The experiment concluded that, 25 per cent of NPK and 42.85 per cent of irrigation water can be saved in the cultivation of cardamom.

S4 P18

Phenotypic diversity, virulence and genetic characterization of *Colletotrichum gloeosporioides*, the incitant of leaf blight of small cardamom in South India

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Leaf blight incited by *Colletotrichum gloeosporioides* is a serious threat to the cultivation of cardamom in India. In the present study, an attempt was made to isolate and characterize the pathogen both morphologically and on molecular basis. Significant variations were observed in twenty isolates with respect to conidial dimensions, length of conidia ranged

from 7.8-21.5 μm . Width of the conidia ranged from 3.3 to 7.8 μm . Isolate CD14 recorded the highest width of conidium (7.8 μm) and lowest width was observed in CD8 isolate (3.3 μm). Variation was also observed in size and lobes, length and width of appressoria produced by the pathogen. Differential reaction of isolates to three varieties revealed that CD5, CD8 and CD7 are highly virulent based on lesion area. Molecular characterization with RAPD, SSR and ISSR primers showed that RAPD and SSR markers are not linked to any characters of pathogen but ISSR primers shows linkage to virulence of the pathogen.

S4 P19

Transcriptome analysis of small cardamom associated with capsule rot disease

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Transcriptome sequencing was performed for both control and disease stressed small cardamom [*Elettaria cardamomum* (L.) Maton] leaf tissues. RNA-seq generated 46,931,637 and 31,682,496 raw reads and totally 9.93GB and 6.63GB of sequence data for cardamom control and stressed samples, respectively. The raw data were submitted to NCBI SRA database of under the accession numbers SRX2512359 and SRX2512358 for the control and diseased samples. The raw reads were quality filtered and assembled using TRINITY *de novo* assembler which created 1,11,495 (control) and 91,096 (diseased) contigs with N50 values 3013 (control) and 2729 (stressed). The data was further used to identify significantly differentially expressed unigenes between control and stressed samples. Assembled unigenes were further annotated and evaluated *in silico* to predict the function using publicly available databases and gene annotation tools. Six-frame translation was performed on the transcriptome to generate peptides using transdecoder. Annotation was done by aligning the transcriptome as well as peptides against uniprot, sprot and Pfam using blast. The analyses resulted in several transcripts expressed at varying levels in the studied samples.

S4 P20

Analysis of genetic variability in ginger (*Zingiber officinale* Rosc.) using ISSR markers

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In this study, 100 universal inter simple sequence repeats (ISSR) primers were used to analyse 50 ginger genotypes which includes North-Eastern landraces, red ginger genotypes, released varieties and a *Zingiber zerumbet* accession to determine their genetic diversity. Out of 100 ISSR markers screened 62 were showing good amplification and a total of 594 bands were generated, of which 370 were polymorphic. Mean percentage of polymorphic bands was 59.96%. Cluster analysis based on the Unweighted Pair Group Method with

Arithmetic Averages (UPGMA) revealed three main clusters for the ISSR data. Cluster I comprised of North Eastern India local genotypes and released varieties of ginger in India; cluster II comprised of red ginger type landraces and cluster III clearly separate *Z. Zerumbet* from other ginger genotypes with least similarity. These results showed a great interspecies genetic diversity but less significant differences among the ginger genotypes and released varieties. This study also lead to identification of unique polymorphic marker for some released varieties such as Karthika (IS02), Suruchi (IS02, ISSR10) and KAU Chandra (UBC 857). These ISSR markers can be used in varietal authentication and the DNA fingerprinting of these varieties.

S4 P21

Characterization and evaluation of multi trait rhizobacteria for growth promotion, mineral solubilization and rhizome rot suppression in ginger

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Hundred bacterial isolates were isolated from soils collected from the rhizosphere of ginger and turmeric grown in Kozhikode and Wayanad districts of Kerala state, Mysore and Chamarajanagar districts of Karnataka, Coimbatore and Erode district of Tamil Nadu, Guntur and Krishna district of Andhra Pradesh and Nizamabad and Jagtial district of Telangana. These isolates were characterized for their morphological, biochemical, and nutrient mobilization traits under *in vitro*. Eighteen isolates were shortlisted based on antagonistic studies against major pathogens of spices and ability to solubilize minerals. Among the 18 bacterial isolates tested against fungal pathogens, isolates IISRGB1, IISRGB2, IISR GB7(3) and IISR TB4 showed maximum antagonistic activity against *Pythium myriotylum*, *Phytophthora capsici*, *Exserohilum rostratum*, *Macrophomina phaseolina* under *in vitro* conditions. The isolates IISR GB7 (3) (*Bacillus* spp.) isolated from soil sample collected from Chamarajanagar, Karnataka and the isolate IISR TB4 (*Bacillus safensis*) isolated from soils of Guntur, Andhra Pradesh were effective against *P. myriotylum*, *E. rostratum* and *C. gloeosporioides* infecting ginger. The plants challenge inoculated with the soft rot pathogen *P. myriotylum*, showed yellowing of emerging tillers one week after inoculation, whereas the ginger rhizomes treated with the bacterial isolate IISRGB7 (3) (*Bacillus* sp) and IISR TB4 (*Bacillus safensis*) did not develop soft rot symptoms. Out of the 100 isolates, eight isolates could solubilize phosphorus and six isolates could solubilize zinc under *in vitro* conditions. Greenhouse study revealed that both the isolates registered significantly higher sprouting, lower disease incidence and greater rhizome yield. The results indicated that the isolates IISRGB7 (3) and IISR TB4 showed remarkable capacity to enhance growth, suppress the soft rot disease and to solubilize P and Zn under *in vitro* and *in vivo* conditions and we recommend the integration of bacterial isolates, IISRGB7 (3) (*Bacillus* sp) and IISR TB4 (*Bacillus safensis*) into the nutrient and disease management schedules for ginger.

S4 P22

Defense enzymes in ginger genotypes induced by rhizome rot (*Pythium aphanidermatum* (Edson) Fitzp.)

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Rhizome rot caused by *Pythium aphanidermatum* is one of the major production constraint in ginger causing a loss of 30 to 100 per cent. Lack of resistant/tolerant varieties also aggravates the disease. An attempt was undertaken at College of Agriculture, Vellayani during the year 2018-2019 to study the defense enzymes by induction of rhizome rot in twenty ginger genotypes collected from farmers field and two control varieties 'Karthika' and 'Rio-de-Janeiro' by *Pythium aphanidermatum*. The pot experiment was laid out in a completely randomized design with five replications at Department of Plantation Crops and Spices. Healthy rhizomes of 20 genotypes and two control were disinfected, sown in pots containing sterilized potting media of coir pith and FYM in the ratio 3:1 and maintained at ordinary temperature and day length. Two month old plants were inoculated with 20 ml of inoculum. The pots of inoculated plants were kept saturated with water from the day of inoculation. Disease incidence and severity were recorded at weekly intervals for 3 weeks. Defense enzymes such as peroxidase, polyphenol oxidase, lipoxygenase and phenylalanine ammonia lyase were analysed before inoculation and symptom development at 10 days after inoculation. Disease incidence and disease severity was least for T₁ (Mananthavady) and T₁₂ (Irinjalakkuda) at three weeks after inoculation. Maximum peroxidase activity was observed in T₁ (Mananthavady) genotype (29.32 Δ OD_{436nm} mg⁻¹ protein min⁻¹), which had a least disease severity of 8.8 at 10 days after inoculation. Polyphenol oxidase activity increased in all genotypes after inoculation. Polyphenol oxidase activity after inoculation was significantly higher for T₁₅ (Nedumkandam) with an activity of 3.51 (OD_{490nm} mg⁻¹ protein min⁻¹). The difference in lipoxygenase activity was significantly higher in T₁₂ (Irinjalakkuda) (6.67 μ mol conjugated diene mg⁻¹ protein min⁻¹) and was on par with T₁₁ (Kazhakootam) which recorded 6.420 μ mol conjugated diene mg⁻¹ protein min⁻¹. Significantly higher difference in Phenylalanine ammonia lyase activity was observed in T₁₈ (Kottiyoor) and T₂₁ (control-Karthika) which produced 1.74 μ mol cinnamic acid mg⁻¹ protein min⁻¹. In the present investigation, after one week of inoculation, no symptom development occurred, while at three weeks after inoculation, percentage disease incidence varied from 80 to 100 per cent and percentage disease severity varied from 31.1 to 64.4. Though all the ginger genotypes including control were susceptible to rhizome rot, T₁ (Mananthavady) and T₁₂ (Irinjalakkuda) showed comparatively less disease severity to rhizome rot. Defense enzymes such as peroxidase in T₁ (Mananthavady) and lipoxygenase in T₁₂ (Irinjalakkuda) can be suggested as a marker for defense mechanism and each genotypes expressed different elicitation of defense enzymes during infection.

S4 P23

Direct *in vitro* regeneration of red ginger (*Zingiber officinale* Rosc.) through rhizome buds

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The red ginger is one of Southeast Asia's indigenous gingers that has high essential oil and medicinal properties. Previous studies have shown that induction of polyploidy can enhance yield and quality attribute, which requires efficient regeneration system. In this study, an efficient direct *in vitro* plant regeneration protocol for red ginger has been established by using the rhizome buds as explants. The response of two genotypes (North east red ginger and exotic red ginger) were studied for shoot and root initiation and growth based on five different concentrations of BAP (1.0, 2.0, 3.0, 4.0, 5.0 mg/l) and a control using MS media. The results indicated that shoot multiplication was significantly high at 1 mg/l in North east red ginger (3.80) compared to exotic red ginger, the maximum shoot multiplication was at 5 mg/l (3.30). Maximum shoot length (4.40) was recorded at 1 mg/l in North east red ginger, whereas in exotic red it was recorded at 2 mg/l. Significantly highest number of roots were recorded at 5 mg/l in Exotic red ginger (10.10) and North east red ginger (8.10) was observed in 3 mg/l. The root length was significantly high in Exotic red ginger (5.70) and North east red ginger (4.99) at 1 mg/l concentration. Our results of direct *in vitro* regeneration may make a significant contribution to the development of improved red ginger materials for high essential oil and medical applications through *in vitro* polyploidy induction.

S4 P24

Establishment of *Methylobacterium komagatae* IISR GPPFM13 as a liquid bio-stimulant for the improvement of the ginger yield

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Genus *Methylobacterium* is abundantly present in the phyllosphere which promotes growth and development of the host plant by producing a variety of phytohormones. Isolated *Methylobacterium komagatae* IISRGPPFM13 strain is a Gram negative, epiphytic, methanol utilizing pink pigmented facultative methylotrophs. This bacterium possessed antifungal activity, production of IAA, hydrolytic enzymes, siderophore and efficacy of solubilizing the minerals also. The study revealed that the culture supernatant having the ability of exhibiting the antagonistic effect on fungal pathogens. Based on the results, liquid bioformulation containing methanol as the carbon source, was evaluated for disease incidence and plant growth. The treated rhizome started to sprout without any infection/no growth in the control. Well grown plants were selected and one set of plants were treated (drenching + spraying) with IISRGPPFM13 culture broth. Yellowing due to infection by *Pythium myriotylum* started on the 4th day of inoculation in untreated plants and on the 12th day the whole plant collapsed, whereas plants treated with IISRGPPFM13 remained healthy in the infected conditions. In a plot study, the culture demonstrated efficacy in ginger cultivation as it inhibited successfully the mycelial growth of the *Pythium*

sp. causing soft rot of ginger. Experimental plots treated by drenching with foliar spraying (T4), spraying (T3), drenching (T2) and seed treatment (T1) were also resistant to infection. Among the five experimental plots, highest difference was illustrated in the plot, of which, drenching with foliar spraying T4, was done. The maximum fresh rhizome yield of 1.18 kg/rhizome was recorded with the T4, followed by T3, T2, T1 (1.09, 0.97 and 0.30 kg/rhizome respectively). Whereas, the lowest fresh rhizome yield T5 (0.07 kg) was recorded in control because of *Pythium* sp. infection. The application of PPFMs improved the plant & soil microbial activities which could help to sustain soil fertility and productivity might be the reason for higher yield in ginger. In this study, all plants were affected with leaf spot diseases after six months. In the harvested rhizome, it was observed with various degrees of infection with *Macrophomina*. It may be concluded that application of PPFMs in dual mode was the best treatment, i.e. drenching followed by foliar spray of PPFMs for high yield and quality of ginger. *M. komagatae* IISRGPPFMs gave a promising result, and better plant management could be achieved provided measures taken from the phase of seed selection and curing with dipping in PPFMs solution.

S4 P25

Growth, yield and quality of black ginger (*Kaempferia parviflora* wall ex baker) in the humid tropical conditions

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Kaempferia parviflora belonging to family Zingiberaceae is popularly known as black ginger or Thai ginseng. In Thailand, the rhizomes of *K. parviflora* are used as aphrodisiac in traditional medicine. The present study was undertaken at Department of Plantation crops and Spices, Kerala Agricultural University, Thrissur to evaluate *K. parviflora* in terms of morphology, floral biology, yield and quality. Three collections of *K. parviflora*, one each from Thailand; IISR, Kozhikode and BSI, Shillong were evaluated in the study. The evaluation was carried out consecutively for two years (2017-18 and 2018-19). *K. galangal* was used as the reference crop. All the collections of black ginger performed well under 50 % shade and the crop completed its life cycle in eight months. The rhizomes of *K. parviflora* were irregular in shape, branched or palmate with brown coloured outer scale and purple inner core; off white root tubers were present in all collections. Days to sprout ranged from 15.42 to 18.25. At 180 DAP tiller production reached the peak and the significantly highest value was registered by the genotype, BSI-1 (6.67). Leaf area, fresh and dry weight of leaves recorded significantly highest value (249.42 cm², 122.58 g, 11.23g) in the genotype KCP-2 at 180 DAP. Significantly highest (114.60 g, 35.90 g) fresh and dry weight of rhizomes was recorded by the genotype KCP-1. Drying per cent ranged from 31.51 to 42.15. Flowering was observed from May to November; flowers were bisexual, complete, trimerous and zygomorphic. Average number of flowers was 14.2 per inflorescence. The time of anthesis was 5.00 am to 7.15 am and stigma was receptive up to eight hours after the anthesis. The seed set was observed and vivipary was reported for the first time. The volatile oil and oleoresin content of rhizome ranged from 0.20 to 0.21% and 2.03 to 4.17%, respectively. The starch, total sugar, total free amino acid and flavonoid content were 13.2 mg, 9.00 mg, 0.49 mg and 26.07 mg, respectively. 34 chemical compounds were detected in GCMSMS profile

of volatile oil and eight compounds from the profiling of ethanolic extract of rhizome by GCMS. Based on the growth and yield parameters, the best performing genotype was Thailand collection, KCP-1 followed by Shillong collection BSI-1. In comparison with *K. galanga*, *K. parviflora* also performed well under humid tropical conditions and this valuable plant can very well be brought into commercial cultivation.

S4 P26

***In vivo* induction of polyploidy to create variability in ginger characters**

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Breeding in ginger is limited mostly to clonal selection because ginger displays high sterility as a result of chromosomal aberrations such as translocations and inversions. Hence other breeding methods such as polyploidy breeding are required to create variability. In an ongoing experiment at College of Agriculture, Vellayani a promising genotype evaluated in the Department of Plantation Crops and Spices was subjected to polyploidy induction *in vivo* by hole method. A hole of 3 mm diameter and depth was made close to the sprouting bud using a needle and 1 ml of colchicine solution of concentration 0.1% was applied into the hole. The treatment was done between 6 am to 9 am; the period of treatment was four hours and repeated for two consecutive days. Hundred rhizome bits of the promising genotype were treated with colchicine and the days to sprouting; sprouting and survival percentage were recorded. The number of days taken for sprouting was 15 days in diploids while the treated plants sprouted at 33 days. The sprouting percentage of the treated plants was 43% while 100% of diploids sprouted. Survival of treated plants was lower than that of the control and among the 100 rhizomes treated only twelve survived. At 90 days, the treated plants of the genotype recorded a maximum height of 26 cm compared to 37 cm in the control plants while at 120 days the plant height recorded in the same variety was 39.2 compared to 41.2 cm in the control. The treated plants recorded maximum tiller production (7 numbers) at 120 days compared to control (5 numbers). Among the twelve treated plants that survived, five were polyploids from chromosome counting. Stomatal length and breadth varied among the treated and control plants. Stomatal length and breadth recorded in the treated plants was 4.34 and 0.42 μm respectively while the diploids showed length and breadth of 3.63 and 2.27 μm respectively.

S4 P27

Influence of planting time and harvest on yield and quality of ginger (*Zingiber officinale* Rosc.) cv. Nadia

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An experiment was conducted on different planting time and harvest on yield and quality of ginger (*Zingiber officinale* Rosc.) cv. Nadia at the Horticulture experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Medziphema, Nagaland University, during 2018 – 2019. The experiment was laid out in Split Plot Design

with dates of planting (M) as main treatment viz, March (M₁), April (M₂) and May (M₃) and five harvesting time (H) as the sub-treatments viz, 6 MAP (H₁), 7 MAP (H₂), 8 MAP (H₃), 9 MAP (H₄) and 10 MAP (H₅) with three replications. The study revealed that harvesting time effectively influenced the quality of ginger. Planting time showed significant effect on almost all the characters except for fibre content. The quality of ginger rhizome such as oil content, dry recovery and oleoresin content had significant influence on both the planting time and the harvesting time. The treatment (M₂H₃) i.e. April planting time and harvesting at 8 MAP exhibited higher yield and yield attributing characters viz. length of finger (8.69 cm), girth of finger (8.09 cm), fresh weight of rhizome plant⁻¹ (1310.3 g), yield plot⁻¹ (11.98 kg), and yield ha⁻¹ (31.53 t). Planting in the month of April and harvesting at 9 MAP (M₂H₄) recorded better quality rhizome with high oil (2.83%) with less fibre content (4.9%) followed by planting in April and harvest at 8 map (M₂H₃).

S4 P28

Variability in quality and essential oil profiling of indigenous and exotic ginger (*Zingiber officinale* Rosc.) genotypes

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The present study reports variability for essential oil profiling among 13 genotypes of ginger (nine exotic and four indigenous) by using GC/MS analysis. Significant differences among the genotypes were observed for various quality characters. Rio-de- Janeiro recorded the highest oil (2.76%) and oleoresin content (6.69%). Among the exotic genotypes Acc. 869 (2.44%), recorded the highest essential oil content followed by Acc. 393 (2.42%) followed by Acc. 833 and Acc. 873 (2.10%). Acc. 869, Acc. 874, Acc. 873 and Acc. 393 recorded higher oleoresin content of 5.88%, 5.63%, 5.34% and 5.28%, respectively. The exotic genotypes such as, Acc. 607, Acc. 736 and Acc. 393 recorded the less crude fibre content (<5%). Whereas, Acc. 869 recorded the higher crude fibre content of 7.85%. The volatile oil profile showed that sesquiterpene hydrocarbons were the major class of compounds identified followed by monoterpene hydrocarbons. The principal compound identified in ginger essential oil was α - Zingiberene and it was highest in Acc. 393 (30.49%) followed by Maran (30.32%). The present study revealed that most of the exotic accessions were recorded higher quality parameters, hence can be used as a potential source for various food and pharmacological industries.

S4 P29

Yield and yield attributes in mango ginger (*Curcuma amada* Roxb) as influenced by rhizome weight and nutrient levels

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A field experiment was conducted at College of Horticulture, Mudigere during 2017-18, to standardize the nutrition and seed rhizome weight for higher yields of mango ginger, *Curcuma amada* Roxb. The treatments consisted of two factors viz., rhizome weight (W₁-20g,

W₂-40g, W₃-60 g) and nutrition levels (N₁-Control, N₂-60:50:100 kg NPK/ha, N₃-90:75:150 kg NPK/ha, N₄-120:100:200 kg NPK/ha NPK, N₅-150:125:250 kg NPK/ha, N₆-180:150:300 kg NPK/ha). Among 18 treatment combinations, W₃N₆ (rhizomes weighing 60g with 180:150:300 kg NPK/ha) recorded highest number of primary fingers per clump (7.96), number of secondary fingers per clump (16.43), length of rhizomes per clump (17.45 cm), width of rhizomes per clump (16.10 cm), yield per plant (358.70 g) and yield per hectare (35.86 t/ha).

S4 P30

Analysis of genetic variability, genetic parameters, character association and genetic divergence of turmeric (*Curcuma longa* L.) germplasms

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The present investigation was carried out at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India during 2017–2019 to screen 200 turmeric germplasms for rhizome yield and quality. The experiment was laid out an augmented block design consisting of 20 blocks with two checks *viz.*, BSR-2 and CO-2. High magnitude of phenotypic and genotypic coefficient of variation exhibited weight of primary rhizome per plant PCV (47.93%) and GCV (47.89%) and number of secondary rhizome per plant PCV (48.46%) and GCV (48.36%). The estimate of broad sense heritability and genetic gain was high for weight of mother rhizome per plant (99.48, 97.05) and weight of primary rhizome per plant (99.85, 98.58). Correlation coefficient among the traits revealed that weight of primary rhizome per plant (0.954), weight of mother rhizome per plant (0.851) and weight of secondary rhizome per plant (0.839) exerted high significant and positive correlation with rhizome yield per plant. Multivariate analysis techniques allowed an effective study of genetic divergence and the grouping of the 200 germplasms into 62 clusters. The principal component analysis revealed that six principal components namely PC1, PC2, PC3, PC4, PC5 and PC6 with eigen values 8.83, 3.52, 2.02, 1.53, 1.24 and 1.04, respectively, have accounted for 75.76% of the total cumulative variability among germplasms.

S4 P31

Effect of different plant growth regulators on growth and yield of turmeric

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The field experiment on effect of different plant growth regulators on growth and yield of turmeric was conducted at Turmeric Research Scheme, Agricultural Research Station, K. Digraj, District Sangli, Maharashtra, India during the year 2016-17. The experiment was laid out in a randomized block design with three replications and eight treatment combinations comprised of Absolute Control, IBA 20 ppm, GA₃ 20 ppm, 6 BA 20 ppm, Paclobutrazol 20 ppm, IBA 20 ppm + GA₃ 20 ppm, IBA 10 ppm + 6 BA 40 ppm and GA₃ 20 ppm + 6 BA 20 ppm. The spraying was undertaken at 20 days intervals starting from

45 DAP and in all five sprayings were given per treatment. The results revealed that the application of GA₃ 20 ppm + 6 BA 20 ppm recorded the highest leaf area (586.80 cm²) which was at par with the treatments GA₃ 20 ppm (568.61 cm²), 6 BA 20 ppm (549.87 cm²) and Paclobutrazol 20 ppm (528.39 cm²) followed by Control (497.95 cm²). The maximum height of plant (126.33 cm) after 150 days after planting was recorded in the treatment GA₃ 20 ppm + 6 BA 20 ppm which was at par with GA₃ 20 ppm (126.20 cm), 6 BA 20 ppm (124.67 cm), Control (114.53 cm) and IBA 20 ppm + GA₃ 20 ppm (110.13 cm). The maximum number of leaves per tiller (15.27) was recorded in the treatment GA₃ 20 ppm + 6 BA 20 ppm ppm, which was at par with GA₃ 20 ppm (14.13), 6 BA 20 ppm (13.40) and Paclobutrazol 20 (13.13). The highest number of tillers (3.53) was recorded in the treatment GA₃ 20 ppm + 6 BA 20 ppm which was at par with GA₃ 20 ppm (3.33), 6 BA 20 ppm (3.13), Paclobutrazol 20 ppm (3.13) and Control (3.07). The highest fresh as well as dry yield of rhizomes was recorded by GA₃ 20 ppm + 6 BA 20 ppm (441.55 q ha⁻¹ and 90.48 q ha⁻¹, respectively), which was at par with GA₃ 20 ppm (431.56 q ha⁻¹ and 87.18 q ha⁻¹, respectively), 6 BA 20 ppm (419.36 q ha⁻¹ and 86.64 q ha⁻¹, respectively) and Paclobutrazol 20 ppm (381.58 q ha⁻¹ and 79.00 q ha⁻¹, respectively). The highest weight of secondary rhizomes (fingers) was recorded in the GA₃ 20 ppm + 6 BA 20 ppm (696.33 gm plant⁻¹) which was at par with GA₃ 20 ppm (671.67 g plant⁻¹), 6 BA 20 ppm (643.33 g plant⁻¹) and Paclobutrazol 20 ppm (605 g plant⁻¹).

S4 P32

Effect of rhizome size and nursery on growth and yield in turmeric under Eastern Ghat region of Andhra Pradesh

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Turmeric is vegetatively propagated through rhizomes and requires 2000-2500 kg of rhizomes to plant in a hectare. As seed material cost is very high, there is a need to reduce the cost of seed material by adopting alternative planting material and selecting optimum size rhizome or rhizome cuttings. As rhizome is cut and used for the preparation of planting material, the diseased rhizome can be eliminated. So, it helps to produce uniform stand, quality and disease free turmeric seedlings. The results of the present study revealed significant variation for all the characters studied. Differential response was noticed with respect to plant height among the treatments. The maximum plant height was recorded in mother rhizomes (75-90 g) directly planting in the field (T9) (136.84 cm) followed by T7 (131.29 cm) and these two were on par with one another, whereas the shortest plant height was recorded in single node cutting (5-6 g) directly planting in field (86.13 cm) followed by mother rhizome pieces (10-12 g) directly planting in the field. Mother rhizome pieces (10-12 g) (96.29 cm). Experimental data revealed that the maximum fresh rhizome yield per hectare was recorded in mother rhizomes (75-90 g) directly planting in the field (29.64 t/ha) followed by primary full length rhizome (20-25 g) planted directly in the field (25.54 t/ha) and these two were on par with one another. Among the transplanted seedlings, one-month old seedling raised by using two node cutting (8 - 9 g) had shown the maximum yield (23.68 t/ha) and on par with primary full length rhizome (20-25 g) planting directly in

the field. Based on these experimental results it is concluded that farmers can cultivate the turmeric with two node raised seedlings with 350 kg of turmeric seed per acre instead of 1000 kg per acre in traditional practice.

S4 P33

Effects of application of nitrogen on plant growth and root system architecture of turmeric (*Curcuma longa* L.)

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This study investigated the effect of low and high levels of nitrogen on plant growth and root morphology of turmeric. The experiment was carried out in randomized block design with three replications in a pot experiments. The plants were grown in greenhouse conditions for two months. Data were recorded for growth parameters such as the plants height, the number of leaves per plant, the length of leaf, the width of leaf and the *chlorophyll content of leaf*. Also, the root length, surface area, projected area, diameter and root volume were recorded. The results showed that low nitrogen level increased the height of plant, the number of leaves per plant, the length of leaf and the width of leaf compared to control. High level of nitrogen significantly increased plant height, leaf length, number of leaves per plant, leaf width and chlorophyll content of leaf compared to control and low level nitrogen. Nitrogen application resulted in a significantly higher root length, root surface area root volume compared to control. It is concluded that nitrogen application had a significant positive effect on plant growth of turmeric.

S4 P34

Influence of foliar sprays of chitosan on yield of turmeric

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The present study was carried out in the Department of Plantation Crops and Spices of College of Horticulture, Kerala Agricultural University, Thrissur to evaluate influence of chitosan sprays on yield of turmeric varieties *viz.*, Shoba, Prathiba and Wayanad local. The chitosan sprays (0.1%) were carried out from 60 DAP (Days after Planting) to 180 DAP at monthly intervals. Morphological observations were taken at 150 DAP. Foliar application of chitosan increased the number of tillers and leaves per plant in all varieties. Irrespective of varieties, tiller production and number of leaves were high in treatment sprayed with chitosan. Tiller production was higher in Wayanad local (5.5) in treatment sprayed with chitosan. Among the varieties, Wayanad local found to be influenced by the chitosan spray. The fresh rhizome yield of Wayanad local was 36.06 t/ha whereas 30.43 t/ha in Prathibha and 28.0 t/ha in Shobha. The bio stimulant chitosan at 0.1% foliar spray was effective in improving the rhizome yield of turmeric. The results showed that chitosan can be used as an eco-friendly compound to induce growth and yield.

S4 P35

Performance of turmeric (*Curcuma longa* L.) genotypes for yield and yield attributing traits under high altitude conditions of Andhra Pradesh

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The present experiment was conducted to evaluate promising genotypes and released varieties under high altitude and tribal zone of Visakhapatnam, Andhra Pradesh in randomized block design with three replications during *Kharif* 2017-18 at Horticultural Research Station, Chintapalli. Total 14 genotypes were taken for study including one local check and one national check. Observations were recorded on various growth and yield characters. Analysis of variance revealed that a wide range of variation was observed for all the characters. It was observed that among the genotypes the maximum plant height was recorded in IT 10 (169.2 cm) followed by Roma (151.67 cm) and the number of tillers and fresh weight clump was recorded in TCP-191 (3.33; 741.02 g, respectively) followed by RH-9/90 (3.1.3; 581.51, respectively). It was recorded that yield/ha was highest in TCP-191 (48.49 t) followed by IT-23 (40.53 t). Dry recovery was highest in LTS-2 (27.94 %) followed by Roma (27.65%). Thus, these genotypes may be recommended for commercial cultivation under high altitude and tribal area of Andhra Pradesh. They can be further evaluated to identify best genotypes suitable for cultivation at other locations and further used in breeding programmes.

S4 P36

WCL 25 - A superior Wayanad turmeric accession for curcumin yield

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An experiment was laid out in Randomised Block Design at College of Horticulture, Kerala Agricultural University, to evaluate the curcumin yield of turmeric accessions collected from Manathavady, Vythiri and Sultanbathery taluks of Wayanad District. Variability was observed in rhizome and biochemical characters. Cluster dendrogram was prepared based on parameters like plant height, girth of the main tiller, number of leaves and tillers, leaf length, leaf width, length and width of primary rhizome, rhizome internodal length, fresh yield per plant, fresh yield per plot, fresh yield per hectare and biochemical characters like curcumin content, oleoresin and oil. It shows that variability exists between different accessions collected from different locations of Wayanad District. The curcumin yield was highest in WCL 25 (551.40 kg ha⁻¹) with 9.31 per cent curcumin. The curcumin content was 10.18 per cent in accession WCL 5 and curcumin yield was 286.06 kg ha⁻¹. Accession WCL 25 was found superior in fresh yield (32.32 t ha⁻¹) and dry yield per hectare (5.56 t ha⁻¹). The rhizome of WCL 25 was compact, plumpy and horizontal in branching with orange coloured rhizome inner core. Accession WCL 25 has a rhizome girth of 2.86 cm with a length of 7.73 cm for primary rhizome and internodal length of 1.45 cm. Oil and

oleoresin content of accession WCL 25 was 1.83 per cent and 18.57 per cent, respectively. These accessions having good quality traits can be included in future crop improvement programmes.

S4 P37

Yield enhancement through planting of sprouted rhizome (transplanted) of turmeric variety Prathibha under hilly region

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To achieve optimum utilization of resources and to enhance the productivity of turmeric var. Prathibha, a field trial was conducted by taking different methods of sprouting [Pro tray (T_1), sand bed (T_2), moist and shaded condition (T_3) along with conventional method of direct sowing (T_4)] with five replications in a randomized block design at College of Horticulture, Sirsi, Uttara Kannada Karnataka, India during 2016-17 and 2017-18. Rhizome bits of 5 g were prepared during second fortnight of March and allowed to sprout in treatments T_1 , T_2 and T_3 . Sprouted rhizomes were transplanted in the main field with the receipt of pre-monsoon showers (May second fortnight) along with rhizomes of 20 g size (direct sowing). However, irrigation was provided during rainless period till the commencement of regular monsoon (June second fortnight). Significant variation was observed for yield and yield attributes. Among the treatments sprouts raised under moist and shaded condition recorded the maximum weight of rhizome (205.34 g plant⁻¹), mother rhizome weight (32.63 g plant⁻¹) and yield (27.93 t ha⁻¹). Economic analysis of transplanted turmeric was also worked out. The treatment T_3 (moist and shaded condition) recorded the highest net returns of Rs. 9.93 lakh ha⁻¹ with B: C of 8.00. The lowest B:C of 3.05 was recorded by conventional method of direct sowing (T_4). The present technology results not only in yield enhancement but also reduces the cost of planting material (Seed rhizome) leaving sizable profit to growers.

S4 P38

Assessment of genetic divergence in chilli (*Capsicum annum* L. var. *acuminatum*) genotypes in mid hilly regions of Uttarakhand

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The present investigation was carried out at the "Vegetable Research cum Demonstration Block", College of Horticulture, VCSG UHF, Bharsar, during *Kharif*, 2016-17 to evaluate diverse germplasm of Chilli. Genetic diversity in chilli genotypes based on 24 characters was estimated using Mahalanobis's D^2 statistics. The genotypes were grouped into five different clusters by non-hierarchical clustering. The experiment was laid out in a Randomized Completely Block Design with three replications. Genetic diversity studies

grouped 19 chilli genotypes into five divergent clusters. Maximum genotypes were placed in cluster III (9 genotypes) followed by cluster IV (5 genotypes). Highest intra-cluster distance was observed for cluster III (580.93) and minimum in cluster IV followed by cluster V. Whereas, highest inter cluster distance (2384.003) was recorded between cluster II and V. Cluster IV and V was observed to be the most important with maximum cluster means for most of the valuable traits. Fresh fruit yield per hectare contributed maximum towards total genetic divergence followed by ascorbic acid (mg) and dry fruit yield per plant (g). Based on genetic divergence studies, best performing genotypes from cluster V, IV, III and II can offer promise for their direct use as varieties and as potential parents in future breeding programmes to isolate transgressive segregants.

S4 P39

Assessment of genetic variance in chilli (*Capsium annuum* var. *annuum*) genotype under semidry conditions of Tamil Nadu

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An investigation on genetic variance in chilli under semidry conditions of Virudhunagar District, Tamil Nadu was carried out with 74 accessions which indicated that the phenotypic coefficient of variation (PCV) was observed to be the highest compared to genotypic coefficient of variation (GCV) for all the characters under study. The phenotypic and genotypic coefficient of variations observed to be ranged from 7.69 to 46.91 per cent and 6.68 to 45.83 per cent, respectively. Among all the traits, of the study, pods per plant (44.04 and 41.88 per cent), dry pod yield (46.91 and 45.83 per cent) registered high PCV and GCV values, respectively, followed by the yield traits of fresh pod weight (38.55 and 36.72 per cent), dry pod weight (38.25 and 38.02 per cent) and seeds per pod (32.83 and 31.24 percent) indicating the existence of great diversity for these traits. High magnitude of PCV and GCV indicated the existence of substantial variability that could be potentially exploited through direct selection. The broad sense heritability values for most of the characters was high and it was noted to be ranged from the lowest value of 52.04 per cent (capsaicin) to the highest value of 98.82 per cent (dry pod weight). Very high values of heritability (more than 80 per cent) was observed for most of the traits. Such traits would act as important selection indices due to their close correspondence between genotype and phenotype values arising from relatively smaller contribution of environment to the phenotype. Further, it was noted that high heritability estimates (60-80 per cent) were observed for chlorophyll stability index (79.83 per cent), nitrate reductase activity (77.44 per cent), relative water content (74.71 per cent), fruit girth (73.48 per cent), chlorophyll 'b' (70.71 per cent) and fruit length (70.07 per cent). High estimates of heritability in quantitative characters was found to be useful for selection based upon phenotypic performance. The genetic advance as per cent of mean (GAM) *i.e.*, genetic gain ranged from 11.29 (days to flowering) to 92.24 (dry pod yield per plant). Among the 74 chilli genotypes the genetic advance as per cent of mean was observed for most of the characters of the study *viz.*, dry pod yield per plant (92.24 per cent), fresh fruit yield per plant (90.96 per cent), number of fruits per plant (82.03 per cent),

dry pod weight (77.86 per cent) and fresh fruit weight (72.07 per cent) which exhibited high genetic advance along with high heritability of the characters of the study and these traits could be taken into consideration for screening of chilli genotypes for specific traits improvement programme. High GCV along with high heritability and genetic advance provide better information than other parameters alone.

S4 P40

Assessment of *per se* performance of chilli (*Capsicum annuum* L.) hybrids in Salem District of Tamil Nadu

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A field experiment was conducted as an on farm trial in five different locations of Salem district during Kharif season of 2017 in chilli using hybrids Arka Harita and TNAU Chilli Hybrid CO 1 with Sierra Hybrid as check hybrid. Arka Harita showed profuse flowering and continuous fruit setting character with tolerance to powdery mildew and TNAU Chilli Hybrid CO 1 is moderately resistant to fruit rot disease. Both are high pungent high yielding hybrids. The results showed that TNAU chilli hybrid CO 1 recorded highest individual fruit weight of 30g followed by Arka Harita with individual fruit weight of 28 g. The check hybrid Sierra recorded lesser fruit weight of 23 g. Regarding yield attribute, Arka Harita recorded highest yield per hectare (28.2 t/ha) followed by TNAU Chilli Hybrid CO1 (26 t/ha) which might be due to the more number of fruits per plant in Arka Harita hybrid. Farmers preference as well as market preference in Salem District is more for TNAU Chilli Hybrid than Arka Harita because of its bigger size fruits with high pungency and high yield. Regarding BC ratio, Arka Harita recorded 2.13 as against 1.97 in TNAU Chilli hybrid CO 1. Least BC ratio was recorded in the private hybrid Sierra in Salem District.

S4 P41

Differential responses of micronutrients (Fe, Zn, Ca, Mg and B) on growth and seed quality in chilli (*Capsicum annuum* L.)

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Micronutrients play a catalytic role in nutrient absorption and balancing other nutrients. However, during recent years, the deficiency of micronutrients is observed in several chilli growing areas affecting the productivity of chilli. The causes for these nutrient deficiencies may be due to judicious use of inorganic fertilizers, intensive cropping system, loss of top soil by erosion and leaching. Therefore, proper plant nutrition through micronutrient is one of the essentials in improving the growth, yield and quality. In recent years, the role of these micronutrients is gaining more importance particularly in chilli to boost not only the productivity but also to improve the seed quality. Seed is the primary input which plays a major role in increase in the yield of the crops. Hence, the present investigation was done to evaluate the effect of pre harvest spray of micronutrients (Fe, Zn, Ca, B and Mg in different combinations and alone) on yield and seed quality of chilli at HRS, Lam in

randomized block design with three replications. The foliar application of the treatments included individual spray of Zinc sulphate (0.2%), Ferrous sulphate @ 0.2%, Calcium nitrate, Magnesium sulphate, 0.2%, Boron 0.1% and combination of all these micro nutrients was done three times i.e., at 60,90 and 120 days after transplanting. Among the treatments, spraying with Zinc Sulphate (0.2%), Ferrous sulphate @ 0.2%, Calcium nitrate, Magnesium sulphate, 0.2% and Boron 0.1% spray recorded maximum plant height, more number of primary branches, yield (119.1 q/ha), seed yield per plant, number of seeds per pod, germination percentage, root and shoot length of seedling and seedling vigour index I and seedling vigour index II.

S4 P42

Efficiency of DNA markers in identifying fertility restorers in exotic advanced breeding lines of chilli (*Capsicum annuum* L.)

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Chilli (*Capsicum annuum* L.) is an important spice cum commercial crop valued for its pungent fruits that are indispensable ingredients in many cuisines throughout the world. Cytoplasmic male sterility (CMS) and Restorer-of-fertility (*Rf*) are the most important traits in producing F_1 hybrids commercially. A nuclear gene *Rf* can induce normal pollen production in CMS plants resulting in fertility. Molecular markers associated with *Rf* can serve as surrogates to phenotypic selection. The present study was taken up with an objective of assessing the efficiency of reported *Rf* linked markers. Advanced breeding lines (ABLs) developed and shared by world vegetable center (WVC), Taiwan were genotyped with reported *Rf* gene linked two Sequence Characterized Amplified Region (SCAR) and one Cleaved Amplified Polymorphic Sequences (CAPS) markers. Both SCAR markers were successful in detecting 11 out of 18 ABLs as restorers. On the contrary, the CAPS marker detected only 10 out of 18 ABLs as restorers. To validate the above results, a field experiment was conducted including 126 F_1 hybrids synthesized following L \times T mating design involving the same 18 ABLs and seven cytoplasmic male sterile (CMS) lines carrying Peterson sterile cytoplasm. The 126 F_1 hybrids were evaluated for extent of fertility restoration using three reliable techniques namely; study of floral morphology, pollen fertility and pollen viability. Male parents involved in deriving F_1 hybrids with very high pollen load, high number of viable and germinable pollen were designated as restorers and those with very low pollen load and a higher percent of pollen sterility were designated as maintainers. Flower morphology and pollen fertility results suggested 14 out of 18 ABLs tested, as restorers and four as maintainers. The study indicated that SCAR markers CRF3S1S and CRF-SCAR have higher efficiency (79%) to differentiate restorers from maintainers as validated by field experiment. On the contrary, OPP-CAPS has a relatively lower efficiency (71%) to differentiate restorers from maintainers. Hence, markers CRF3S1S-SCAR and CRF-SCAR could reliably be used in detecting restorers which allows commercial exploitation of heterosis.

S4 P43

Evaluation of bird's eye chilli (*Capsicum frutescens* L.) accessions for growth, yield and quality traits under hill zone of Karnataka

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In this study an effort was made to collect and evaluate the local accessions of the bird's eye chilli from wild. The germplasm was collected from its natural habitats from across the state, covering the districts *viz.*, Chickmagalore, Hassan, Udupi, Kodagu and Shivamogga. Thirty-five accessions of bird's eye chilli (*Capsicum frutescens* L.) were evaluated for the growth, yield and quality traits under hill zone of Karnataka in a Randomised Complete Block Design with three replications. Significant differences were observed among the genotypes for all the traits. Nineteen parameters *viz.*, plant height (cm), number of primary branches per plant at harvest, plant spread (cm²), days to first flowering, days to 50 per cent flowering, days taken for fruit set and fruit maturity, fruit length (cm), fruit width (cm), stalk length (cm), stalk width (cm), fresh weight and dry weight of 10 fruits (g), number of seeds per fruit, weight of seeds per fruit (mg), fruit to seed ratio, fruit yield per plant, vitamin-C (mg/100 g), capsaicin content (mg/g) and chlorophyll content (spad units) were taken into consideration under the study. Among the genotypes, Acc.15 is found to be superior in terms of growth parameters *viz.*, plant height (79.81 cm), number of primary branches (7.17) and plant spread (46.46 cm²). The Acc.160 (12.14 kg per plot) and Acc.158 (11.39 kg per plot) were found to be higher yielders of green chilli, Acc.18 (26.67 days) was early maturing type and Acc.133 (120.17 mg per 100 g) and Acc.164 (2.16%) recorded high ascorbic acid and capsaicin content, respectively. The primary data generated in the study could be used for further studies on crop improvement aspects as there are no improved varieties available for cultivation in the region.

S4 P44

Evaluation of chilli (*Capsicum annum* L.) genotypes in vertisols of Andhra Pradesh for yield and quality

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Andhra Pradesh is the largest chilli growing state in India followed by Karnataka and Maharashtra. Besides soil and climatic factors, the performance of genotypes plays an important role with regard to earliness, yield and quality attributes. Hence, the present trial was conducted with an objective to evaluate the performance of different promising chilli genotypes for growth, yield and quality attributes in vertisols of Andhra Pradesh at Horticultural Research Station, Lam. The trial was conducted with seven entries in randomized block design with three replications during 2014 to 2016. Significant differences were observed within the genotypes during both the seasons for the yield and quality

parameters. The pooled data revealed that, among the genotypes evaluated, the genotype Punjab sindhuri was earlier with regard to 50% flowering (59.9 days), high vitamin c content (152.3 mg /100 g), maximum fruit length (12.1 cm), maximum fruit girth (4.1 cm) and recorded highest yield (95.9 q/ha) being on par with LCA-334 (85 q/ha) and AKC-406 (84.9 q/ha). With regard to quality parameters, AKC-406 recorded maximum oleoresin (14.5%), colour value (58.9 ASTA), red (0.77%) and yellow carotenoids (1.04%).

S4 P45

Per se performance of hybrid chillies (*Capsicum annuum* L.) - TNAU hybrid chilli CO1 and Arka Meghana - in Salem District of Tamil Nadu

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A field experiment was conducted as an on farm trial in five different locations of Salem District during Kharif season of 2013 using chilli hybrids TNAU Chilli Hybrid CO 1 and IIHR chilli hybrid Arka Meghana with a private hybrid US611 as check. TNAU Chilli Hybrid CO 1 showed moderate resistance to fruit rot disease with more number of marketable fruits per plant. Regarding yield attributes, TNAU Chilli Hybrid CO1 recorded 4.25 t/ha of green fresh fruit yield and 1.57 t/ha of red ripe dry fruit yield. Whereas the yield of the other hybrid Arka Meghana was 2.57 t/ha of green fresh fruit yield and 0.74 t/ha of red ripe dry fruit yield. The private check hybrid US611 recorded green fresh fruit yield of 2.67 t/ha and red ripe dry fruit yield of 0.89 t/ha. Regarding BC ratio, the TNAU Chilli Hybrid CO 1 has given the highest value of 3.96, whereas it was lesser in private hybrid US611 (2.92) and least in (2.65) in Arka Meghana under Kolathur conditions of Salem District. This might be due to the less incidence of fruit rot in TNAU Chilli Hybrid CO 1 (22%) when compared to the other two hybrids (28% to 88%), which resulted in more number of marketable fruits and marketable yield as well as lesser production cost in TNAU Chilli Hybrid CO 1. Hence, performance of TNAU Chilli Hybrid CO 1 was found to be better for the chilli growing areas of Salem District especially in Kolathur Block.

S4 P46

Dioecy and monoecy in nutmeg (*Myristica fragrans* Houtt.) – A comparative evaluation

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Nutmeg is antecedently considered as typical dioecious in nature, but monoecious trees are reported rarely. Unlike the dioecious nutmeg trees, monoecious trees have three types of flowers mainly staminate, pistillate and hermaphrodite. In the present study, four dioecious and two monoecious nutmegs were characterized and evaluated based on the morphological parameters at the Department of Plantation Crops and Spices, College of Horticulture, Kerala Agricultural University, Thrissur. Flower characteristics of all the accessions were recorded. Univariate analysis of quantitative data from the selected six nutmeg accessions was done using general linear model. Ranking technique was followed to rank the performance of above mentioned accessions for a set of economic parameters viz. fresh and dry nut weight, fresh and dry mace weight and dry kernel weight. Based on the pooled rank scores for fruit characteristics, data of two dioecious and one monoecious

nutmeg accessions namely CF-1, IA-1 and MN-1 were further subjected to statistical analysis. In monoecious nutmeg, the number of pistillate and staminate flowers was three each per 10 cm² and number of hermaphrodite flowers was two per 10 cm². Dioecious accessions had 5-10 pistillate flowers per 10 cm². The nature of fruit splitting in monoecious nutmeg was three halved in 60 per cent of fruits with irregular shaped nut, but that of dioecious one was two halved with regular nut shape. Mace and nut along with the pericarp were persistent on the tree even after fruit splitting in monoecious nutmeg unlike the dioecious one. Fresh nut weight and dry mace weight were significantly higher in the dioecious nutmegs IA-1 followed by CF-1. Dry nut weight and fresh mace weight were significantly higher for dioecious accessions CF-1 followed by IA-1. Kernel dry weight was significantly higher for both the dioecious accessions when compared to monoecious one. Number of fruits per tree was significantly highest in the accession CF-1 followed by IA-1, both dioecious in nature over monoecious nutmeg accession. Similarly, dioecious nutmeg trees were superior over the monoecious in terms of mace yield as well as nut yield per tree. In the present study, occurrence of abnormal flowers and fruits was observed in monoecious nutmeg genotypes. Between the dioecious and monoecious accessions, yield per tree of monoecious nutmeg was only 25% of the yield in dioecious type. Even though nutmeg exhibits polygamomonoecious nature having pistillate, staminate and hermaphrodite flowers on the same tree which otherwise is expected to improve pollination and fruit set leading to higher yield, it does not appear to be a desirable attribute for the crop in terms of economic characters.

S4 P47

Evaluation of nutmeg genotypes under Kanniyakumari region of Tamil Nadu

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Nutmeg is a crop commercially grown in Kanniyakumari District of Tamil Nadu as the mace, nut and flesh fetch good price in the market. The trial was initiated with an objective of collection, characterization and nutmeg genotypes with high yield suitable to Kanniyakumari region of Tamil Nadu. Twenty-five accessions were collected and being maintained from nutmeg growing regions at Horticultural Research Station, Tamil Nadu Agricultural University, Pechiparai, Kanniyakumari district of Tamil Nadu. Morphological characters and yield attributing traits were recorded in order to identify promising accessions. Among the accessions, MF1 recorded maximum tree height (10.25 m) and stem girth (59.16 cm) followed by MF2 recorded tree height (9.47 m), MF5 recorded stem girth (49.77 cm) compared with local check tree height (8.27 m) and stem girth (31.04 cm). MF4 recorded maximum leaf length (20.72 cm), leaf breadth (9.66 cm), No. of fruits (678), single fruit weight (59 g), mace yield /fruit (5.0 g) and mace yield (291 g/ tree) followed by accession MF 17 recorded highest number of fruits (590), MF23 recorded highest single fruit weight (57.5 g) and accession MF 19 recorded mace yield 279 g/tree compared with local check leaf length (20.72 cm), leaf breadth (9.66 cm), No. of fruits (678), single fruit weight (59 g), and mace yield (291 g/ tree) leaf length (17.94 cm), leaf breadth (6.57 cm), No. of fruits (497), single fruit weight (52.50 g), mace yield /fruit (2.0 g) and mace yield (163 g/ tree).

S4 P48

Effect of temperature, physical and chemical treatments on seed quality enhancement in senna (*Cassia angustifolia* Vahl.)

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Senna is an important medicinal plant which belongs to family Leguminosae. Seed germination is the first and foremost pre-requisite in assessing the quality and optimizing yields from a given seed lot. Senna seeds attribute lower germination, usually due to imperviousness of the seed coat and require specific treatments for breaking seed dormancy. A laboratory experiment was conducted at Department of Seed Science and Technology, Anand Agricultural University, Anand, Gujarat during 2018-19. The experiment was carried out to study the effect of temperature, physical and chemical treatments on seed quality enhancement. Firstly, to standardize optimum temperature requirements for germination of senna seeds, four different temperatures were considered viz., 20°C, 25°C, 30°C and 35°C. The results revealed that temperature 25°C showed higher germination per cent (32.33%). In the second experiment, senna seeds were subjected to various physical, chemical and hot water treatments like mechanical scarification, H₂SO₄ (100%) and 100°C water treatments under different durations. The results indicated that mechanical scarification for two minutes increased the germination per cent (94.66%) as compared to control (32.33%) and also improved seedling growth parameters at 25°C.

S4 P49

Physiological and biochemical defense retort of Cinnamon (*Cinnamomum verum*) against leaf miner infestationBalaji Rajkumar*, M Alagupalamuthirsolai¹ & Mohammad Faisal Peeran

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A study was conducted to find the effect of epidermal leaf mining on growth and physiology during high incidence of cinnamon leaf miner at experimental farm of Indian Institute of Spices Research, Regional station, Appangala, Karnataka, India. Incidence of leaf miner was recorded both in young and older leaves. The damage per cent was assessed to select optimum sample for analysis. The maximum leaf area damage of 41-50 per cent was observed in 19.1 per cent leaves and 20.8 per cent leaves with 31-40 per cent damage. Epicuticular wax, CO₂ concentration, gas exchange, chlorophyll fluorescence, photo system (PS) II quantum yield and defense related enzymes were analysed from healthy as well as infested leaves. There was no significant difference observed in wax content of healthy and infested leaves (612.4 µg cm⁻²), However, there was a significant difference found between healthy young and matured leaves (437 µg cm⁻²). Internal CO₂ concentration of infected leaves was 34.97 ppm and it increased compared to healthy leaves. In contrast, the transpiration rate was 1.57x lower than the infested leaves (0.5493 m²s⁻¹ H₂O). Stomatal conductance of infested leaves was 0.6x lower (0.018 mmol m⁻² s⁻¹) than healthy leaves. The infested leaves recorded two times lower net photosynthetic rate than healthy leaves

i.e., $1.231 \mu\text{mol m}^{-2} \text{s}^{-1}$. Similarly, chlorophyll fluorescence was observed 1.10x lower in infected leaves (88.62) than healthy leaves. The maximum PS II quantum yield (Fv/Fm) was significantly higher in healthy leaves (0.75) when compared to infested leaves (0.689). The young infested leaf showed increase in the activity of peroxidase (PO) compared to healthy leaves. Five isoforms of peroxidase were found in young healthy leaves and two isoforms in young infested leaves. The phenylalanine ammonia lyase (PAL) and polyphenol oxidase (PPO) activity were significantly lower and induction of more isoforms of PPO was also found in young infested leaves. Significant increase in catalase (CAT) and superoxide dismutase (SOD) also indicated response of young infected leaves against the insect attack.

S4 P50

Studies on propagation of allspice through grafting

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Allspice (*Pimenta dioica* L.) indigenous to West Indies, also known as 'Jamaican pepper' due to its pepper berries like appearance. The dried unripe berries are the economic part. Allspice is a hard to root hardwood perennial medium tall tree conventionally propagated through seeds, but the seeds lose their viability soon after harvest. Allspice trees are polygamodioecous by its nature hence, identification of the functional male and female trees is difficult till they flower. Therefore, grafting can be one of the effective methods for propagating allspice plants to produce true-to-type plants. No work has been reported so far for successful vegetative method of propagation through grafting.

Therefore, a study was carried out during May 2019 at HREC, Sirsi to know the possibilities of propagation through grafting. The scions (about 10-15cm long with one-year-old maturity) from four different trees of about 8-10 years having regular bearing habit were selected and were grafted (softwood grafting) on to the one-year old seedlings allspice as rootstocks. The graft success (%) was very good in all the four types that ranged from 89.50 to 96.00 per cent. The comparative morphological observations recorded in successful grafts. A maximum plant height (91.7 cm), longer leaves (11.2 cm) and broader leaves (5.15 cm) in AS-3 type while AS-1 plants recorded maximum per cent (96%) graft success, higher no. of branches (4.0) and no. of leaves (42.4) in AS-1 types. The controlled plants recorded lower values for all the morphological characters. Therefore, the present study confirmed that the allspice plants can be easily multiplied by soft wood grafting and used for commercial multiplication.

S4 P51

Initial performance of allspice (*Pimenta dioica* L.): Precocious trees identified under hilly zone of Karnataka

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All spice (*Pimenta dioica* L.) a member of Myrtaceae family, is a slow growing tree with

aromatic leaves. It is of major economic importance, because of its characteristic flavour and aroma. Three years aged plants were observed for initial performance at College of Horticulture, Sirsi, Uttara Kannada, Karnataka, India during 2017-18. Observations were recorded on the initial growth performance of all spice plants raised using seedling and grown under two different ecosystems *i. e.* i) under natural shade of forest and ii) in open area. Generally, it takes five to six years for flowering in all spice plants. Interestingly, out of eight plants grown under natural shade of forest, two plants were precocious and produced flower panicles during 3rd year itself with vigorous vegetative growth. On the contrary none of the trees (out of 16) have flowered during 3rd year of growth in the open condition. There is a need to exploit these trees for commercial cultivation for yield enhancement by vegetative multiplication apart from ascertaining the role of genotype and environment in precocity of allspice.

S4 P52

Effect of different propagation media on seed germination, seedling growth and vigour of *Zanthoxylum rhetsa*

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An experiment was conducted in the year 2017 at College of Forestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli on seed germination, seedling growth and vigour of *Zanthoxylum rhetsa*. There were significant differences in germination and seedling growth behavior of *Z. rhetsa* sown in seven different combination growth media. The results showed that germination percentage, seedling height, number of leaves per seedling, leaf area, shoot dry weight and root length have improved significantly by Soil + FYM (2:1) followed by Soil + Vermicompost (1:1). However, root dry weight and absolute growth rate were improved with Soil + Vermi compost (1:1) followed by Soil + FYM (2:1). Among all the treatments studied, treatment T1 Soil + FYM (2:1) was found the best with regard to growth parameters.

S4 P53

Chhattisgarh Shri Chandrahasini Dhaniya-2 – the India's high yielding desi dhaniya

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Field experiments were carried out at 13 centers of All India Coordinated research Project (AICRP) on Spices during 2015 to 2018. In Coordinated Varietal Trial 2015 series of coriander total 28 genotypes were evaluated for yield and yield attributing traits in Randomized Block Design (RBD) with three replications. The row to row distance was 30 cm and plant to plant distance was 10 cm and recommended agronomic practices were followed for raising good crop. The analysis of variance revealed significant genotypic differences among the treatments. The pooled data over the locations and years revealed

that Chhattisgarh Shri Chandrahasini Dhaniya-2 recorded highest seed yield (14 q/ha) over the national checks Hisar Anand (10 q/ha), and Rcr 728 (11 q/ha) across different AICRP centers of India. During 2018 Chhattisgarh Shri Chandrahasini Dhaniya -2 was recommended in AICRP on Spices workshop and during 2019 it was released by the Central Variety Release Committee for Chhattisgarh, Madhya Pradesh, Rajasthan, Bihar, Uttarpradesh, Harayana, Gujarat, Uttarakhand, Andhra Pradesh and Tamil Nadu.

S4 P54

Development and validation of SSR molecular markers for coriander (*Coriandrum sativum*) using ESTs

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Coriander is a very popular seed spice, but very limited molecular and genomic studies have been undertaken on it. In addition, a lack of coriander molecular markers limits the process of molecular breeding. Problems associated with conventional breeding can be overcome by the use of molecular marker assisted selection. However, only a few molecular markers have been reported in coriander like RAPD and ISSR and a very popular and informative SSR marker is lacking for this crop. To overcome the problem of specific SSRs for coriander we have used the technique through transcriptome analysis. Genic microsatellites or EST-SSRs derived from expressed sequence tags (ESTs) are desired as these are inexpensive to develop, represent transcribed genes, and often a putative function can be assigned to them. ESTs were developed for the coriander crop using RNA sequences of the coriander varieties ACr-1 and CS-6. Microsatellites were developed using the MISA v1.0 software from transcriptomes. *In silico* validation confirmed the SSRs availability at different sizes and distance. These SSR loci will be a powerful tool for coriander breeding programs, MAS, conservation genetic studies and molecular characterization of coriander for duplicity.

S4 P55

Effect of different doses of nitrogen and row spacing on growth and yield of coriander (*Coriandrum sativum* L.)

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Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant belonging to family Apiaceae. It is a dual purpose herb grown for its aromatic leaves and cermocarpic seeds. Nitrogen, a primary nutrient has a substantial impact upon quality and quantity as it enhances the physiological and biological functions of coriander crop. The study was conducted to compare the relative advantages of different doses of nitrogen (50, 60, 70, 80 and 90 kg/ha) and row spacing (30, 40 and 50 cm) in coriander cultivation with reference to morphological, phenological and yield attributes at Horticulture complex, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the Rabi season in 2018-19. The experiment was laid out in complete randomized block design with three replications. The results revealed that among the combinations N3S3 (nitrogen

70kg/ha with row spacing 50cm) recorded significantly higher values for plant height (109.65 cm) followed by N80S30 (108.09 cm) and minimum (81.88 cm) was recorded in N50S40. Number of primary branches increased with higher dose of nitrogen and closer spacing. Maximum number of 7.40 primary branches were observed in N4S1 (nitrogen 50 kg/ha with row spacing 40 cm) which was subsequently followed by N80S50 having 7.34 primary branches and minimum (5.37) was noted with application of 50 kg nitrogen/ha having row spacing of 40cm. Adequate supply of nitrogen under wider spacing lead to vigorous vegetative growth. Minimum days taken to 50% flowering (50.67) was observed in N1S3 (Nitrogen 50 kg/ha in row spacing 50 cm) and maximum (59.68) days taken to 50% flowering was recorded in N5S1 (Nitrogen 90 kg/ha with row spacing 30 cm). The treatment combination of nitrogen 70 kg/ha with row spacing 40 cm showed earliness (92.89 days) whereas, coriander crop grown in combination of N60S40 took 98.65 days to mature. Number of umbels per plant and seed yield improved due to closer spacing and higher dose of nitrogen. The number of umbels (46.04) per plant were significantly higher for N80S30 and N90S50 (45.76) was at par. N50S30 recorded the lowest number of 29.52 umbels per plant. Marked improvement in seed yield was due to vigorous plant growth and profuse branching. The maximum seed yield 15.51 q/ha were recorded in N4S1 (Nitrogen 80 kg/ha with row Spacing 30 cm) treatment followed by N60S40 (15.45 q/ha) and N70S40 (15.12 q/ha). Whereas, minimum seed yield was noticed in N90S40 (6.74 q/ha). It can be concluded that nitrogen and row spacing significantly influence the growth and yield of coriander.

S4 P56

Effect of season and growing condition on yield and quality parameters of coriander (*Coriandrum sativum* L.)

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The coriander (*Coriandrum sativum* L.) is a cool season crop and can be successfully cultivated in *rabi* season on black cotton or other type of heavy soils which have better water retention capacity. The study was conducted at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, for nine months from September 2017 to May 2018, to study the effect of season of sowing on foliage yield and quality of coriander under two different growing condition *viz.*, open field and shade net (50%) with the variety CO (CR) 4. The experiment was laid out in a Randomized Block Design (RBD) with eighteen treatments replicated thrice. When we see the results, coriander grown under shade net yielded well compared to open field condition. In open field condition there was no germination observed during summer months (March, April and May) while in shade net condition slight reduction in yield was observed compared to other months. In case of quality, there were no significant differences observed between open field and shade net condition except for high quality observed in open field condition. In case of the effect of sowing month, October month recorded high yield and quality for both the condition. From the study it can be concluded that, to obtain high yield and high quality coriander, October season under open field condition and year round production under shade net (except summer months) can be suggested.

S4 P57

Effect of time of sowing on growth, herbage yield and quality of *Coriandrum sativum* in plains of Kerala

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A study was conducted in the plains of Kerala to investigate the performance of five coriander varieties for growth, herbage yield and quality in rain shelter during October 2015 to March 2017 in four different times of sowing. The study revealed that irrespective of time of sowing, the varieties CO (Cr-4) followed by CO-2, CO-3 and CO-1, recorded the lowest number of days to seed germination, first leaf, second leaf and third leaf emergence whereas, Arka Isha took more number of days for these parameters. The varieties Arka Isha and CO (Cr-4) yielded highest mean number of leaves in all the times of sowing (16.30 and 15.69). Generally, the crop grown during July-September (S2) exhibited highest number of leaves (16.36) at harvest. Irrespective of time of sowing, the variety Arka Isha performed better with respect to the mean herbage and biomass yield per plant with highest yield during July-September (S2) and the lowest during January-March (S4). The variety CO (Cr-4) was the earliest to show serration of leaves in all the four times of sowing (37.43 days), flowering (40.19 days) and seed set (47.69 days). Whereas, the variety Arka Isha showed delay in leaf serration (49.29 days), flowering (54.05 days), and seed set (63.27 days). The quality aspects like vitamin C and total chlorophyll were highest in Arka Isha (158.98 mg/100 g and 2.20 mg/100 g, respectively). With respect to the total chlorophyll, July-September (S2) sown crop (2.27 mg/100 g) was superior. However, volatile oil content (0.05 per cent -0.06 per cent) was not affected by time of sowing.

S4 P58

Evaluation of coriander *Coriandrum sativum* L. genotypes under normal irrigation and moisture stress contions

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A field experiment was conducted for three years under All India Coordinated Research Project on Spices at Agriculture Research Farm, SKN College of Agriculture, Jobner, Rajasthan (India) during *rabi* season from 2015-16 to 2017-18 for the identification of moisture stress/drought tolerance in coriander. The experiment consisted of 30 genotypes which were randomly selected from the germplasm being maintained at Jobner. These lines were sown in two environments namely E_1 (normal irrigation) and E_2 (moisture stress). Moisture stress was created by applying staggered irrigations (half of that given in normal irrigation). The entries were sown in RBD with three replications in each environment. Each line was sown in a single row plot of 3 m length spaced by 0.3 m in mid-November every year. Check rows were sown all around the experiment. Seed yield and other morphological traits were taken on a random sample of 5 plants and averaged except days to 50% flowering which was recorded on plot basis. TOL (stress tolerance),

SSI (Stress susceptibility index) and STI (Stress tolerance index) were estimated as per standard methods. The analysis of three years' data revealed that coriander genotypes UD 551, UD 566, UD 783, UD 32 and UD 705 in normal while UD 705, UD 492, UD 573, UD 489 and UD 580 in moisture stress conditions were top yielders. Based on stress indices UD 580 found to be the desirable entry for moisture stress/ drought conditions, followed by UD 489, UD 747, UD 717 and UD 573.

S4 P59

Growth and yield traits performance of coriander Acr-1 for seed production

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Coriander cultivated largely for its tender leaves and it is popular for garmish, salad, sandwiches, fruit dish and flavouring ingredients but this experiment was undertaken at seed technology research unit in *rabi* season for seed production purpose under the project Mission on Integrated Development of Horticulture, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani, (MH). An experiment was laid out in randomized block design with coriander variety Acr-1 seed received from ICAR, NRC on Seed Spices, Tabiji, Ajmer. The crop was sown during November 2019 with spacing 25 cm in lines and 15 cm in plants. Observations on plant height, number of branches, days to flowering, umbels/plant, dry weight/plant were undertaken during the crop growth. During the crop growth, atmospheric temperature varied from max (28.94°C) to min (14.77°C) and atmospheric humidity (44.15 to 79.95). The anthesis period of coriander started from 40-45 DAS at this location. The mean values of the observation indicate that the plant height obtained was 88.6 cm, number of branches per plant was 7.5, the total number of umbels/plant were observed in the range of 73-74/plant. Along with seed production this crop is a very good source for the production of honey and in this experimental plot we have established and arranged two honey bee kits for the natural rehabilitation of honey bee habitats. Seed production of coriander is one of the ways of integrated farming for farmers.

S4 P60

Impact of growing environment on growth and yield parameters of coriander under shade net and open field for year round production

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A field experiment was conducted at college orchard, Department of Spices and Plantation Crops, Horticultural College and Research Institute, Coimbatore to study the performance of coriander (*Coriandrum sativum* L.) var. CO (CR) 4 for year round production of foliage under shade net and open field condition. The experiment was laid out in Randomized Block Design (RBD) with three replications to study the effect of different months of sowing and growing condition on production of coriander. Seeds were sown every month from September to May, under both open field and shade net condition and observations on biometric and qualitative traits were recorded. The influence of environmental variables like temperature, relative humidity and light intensity were also studied. The results revealed that the October sown crop performed well both under shade net and open field

condition. However, early germination (7.67 days) was recorded in the coriander raised under shade net when compared to open field condition (11.33 days). Under open field condition, there was crop failure during summer months from March to May. Coriander sown during October showed vigorous growth both under shade net and open field condition recording maximum plant height (29.88 cm and 26.59 cm, respectively), number of primary branches (4.50 and 5.50, respectively) and highest number of leaves (30.63 and 34.44, respectively). Leaf yield per plot in the crops sown during different months showed variations and the highest average yield was recorded under shade net condition (4.71 kg/plot) when compared to open field condition (2.18kg/plot). While October sown crop recorded higher yield (5.69 kg/plot) under both the growing conditions when compared to crops sown during other months. Cost economics of coriander cultivation was worked out for open and shade net condition and the results revealed that net returns was high from the crop sown during October (₹2,25,039/ha) under shade net and B:C ratio was also high for the October sown crop under shade net (3.78). Thus, remunerative coriander cultivation with year round production is possible under shade net condition. Though, the initial cost of establishment is high, farmer can improve the quality of produce and earn sustainable income.

S4 P61

Influence of different growth stages on the quality parameters of coriander (*Coriandrum sativum* L.)

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A study was undertaken to validate the nutrient composition of coriander leaves at all stages of the crop *viz.*, seedling stage (15 DAS), vegetative stage (25-30 DAS), pre-flowering stage (40 DAS), flowering stage (60-70 DAS), immature green seed stage and mature brown seed stage in seven coriander varieties/genotypes *viz.*, CO (CR) 4, CO3, Vilathikulam local, Virudhunagar local, Kolli hills local, Ramnadlocal and Thondamuthur local. The present study revealed that the mineral nutrient composition differed significantly at all stages of the crop. However, the coriander varieties/genotypes exhibited different variation pattern in mineral composition of leaves and seeds. In general, there was a steady increase in the nutrient composition from seedling stage to pre flowering stage with maximum nutrient composition in the pre-flowering stage irrespective of the varieties/genotypes. There was a sharp decrease in the nutrient composition of leaves in the flowering stage with a steady increase of nutrient content in the mature brown seed stage. With respect to mineral composition, CO (CR) 4 registered the highest iron (21.76 mg/100 g), calcium (163.25 mg/100 g), magnesium (69.26 mg/100 g) and potassium (2.54 g/100 g) content in the leaves at pre flowering stage. The flavonoid, quercetin was high in the pre flowering stage of CO (CR) 4 (0.68%) and the least quercetin content was observed in the flowering stage (0.06%). Maximum carbohydrate and dietary fibre content was observed in the seeds at mature seed stage. The same trend was noticed for the beta carotene and ascorbic acid content in the both fresh and dry form of the leaves and seeds of coriander varieties/genotypes at different stages of the crop. However, the coriander leaves in the seedling stage recorded the highest beta carotene content.

S4 P62

Protected cultivation and germination enhancement techniques in coriander *Coriandrum sativum*

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Protected cultivation is considered as an alternative strategy for improved productivity and year round cultivation. Substantial improvements in yield and quality have been reported in vegetables when grown in protected structures under controlled environments. Coriander (*Coriandrum sativum*), although a seed spice, is highly valued for its green leaves that is used as an appetizer and for flavouring dishes. The short stature and duration of the crop widens the scope for inclusion in cropping systems and hi-tech agricultural practices including protected cultivation and vertical farming. The evaluation of the suitability of leafy coriander as a component in a naturally ventilated polyhouse along with other leafy vegetables amaranthus, palak, cabbage, celery and lettuce in two seasons revealed the crop to perform better in the protected condition compared to the open, the yield being 29 per cent greater under protected condition. Seed germination and subsequent establishment in the field was the major crisis faced in the cultivation of coriander. Laboratory investigations have shown the practice of soaking the split seeds taken in small cotton sachets in ordinary water overnight and alternatively keeping the moistened sachets open during the day and closed during the night for one week proved to be a germination enhancement technique in coriander. The germination percentage was 48.3 per cent higher than that in control of no seed treatment at the end of 8 days and the speed of germination was also higher for the former. It can thus be concluded that overnight soaking in water followed by incubation is a suitable seed germination enhancement technique in coriander and protected conditions holds promise for the year round cultivation the crop.

S4 P63

Influence of elicitors on yield and quality of black cumin (*Nigella sativa* L.) varietiesH S Arpitha*, K Umsha¹ & G S Anilkumar¹

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An investigation was carried out at the College of Horticulture, UHS Campus, GKVK, Bengaluru, during November 2018 to March 2019 to study the effect of elicitors on yield and quality of black cumin varieties. The present study consists of three varieties *viz.* Azad Kalonji, AN-20 and Pant Krishna and four elicitors *viz.* salicylic acid, methyl jasmonate, nitric oxide, hydrogen peroxide and with control in 15 treatment combinations. Among varieties, Pant Krishna recorded maximum number of capsules per plant (16.87) and fixed oil content (35.03%), while AN-20 recorded maximum essential oil content (0.33 %), essential oil yield (3.21 kg ha⁻¹) thymoquinone content (19.96%) and thymoquinone yield (0.673 kg ha⁻¹). Among different elicitors tried methyl jasmonate at 100 ppm recorded maximum number of seeds per capsule (79.27) and seed yield per hectare (11.52 q), essential oil yield (3.55 kg ha⁻¹), fixed oil yield (402.45 kg ha⁻¹), whereas nitric oxide at 2 mM recorded maximum essential oil content (0.32%) and salicylic acid at 100 ppm recorded maximum thymoquinone content (19.29%). Among the interaction of varieties and elicitors, Pant

Krishna treated with methyl jasmonate at 100 ppm recorded maximum number of capsules per plant (22.60), seeds per capsule (84.28), while highest thymoquinone content (27.79%) and thymoquinone yield (0.92 kg ha⁻¹) was recorded in AN-20 variety sprayed with nitric oxide at 2 mM. The maximum net returns (₹1,34,644) and B:C ratio (3.54) was registered in Azad Kalonji variety sprayed with salicylic acid at 100 ppm.

S4 P64

Influence of organic and inorganic source of nitrogen and spacing on growth and yield of fennel (*Foeniculum vulgare* Mill.) in Rayalaseema region of Andhra Pradesh

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A field experiment was carried out for two consecutive years (2016 and 2017) in *Rabi* season at Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Anantharajupeta, Dr. YSR Horticultural University, Andhra Pradesh. The experiment was laid out in Randomized Block Design with 11 treatments and three replications. The seeds were sown in two different spacing *i.e.* 45 × 45 cm and 60 × 45 cm with five different combinations of Nitrogen from different sources of organic and inorganic along with bio fertilizers, phosphorous and potassium. The results observed that maximum plant height (169 cm), number of primary branches (11.9) and secondary branches (19.2), number of umbels per plant (116.4) was recorded in 50% RDN (Recommended Dose of Nitrogen) through vermicompost + 50% RDN through urea with a spacing of 45×45 cm. The maximum seed yield (14.2 qha⁻¹) was recorded in the treatment (T₉) 50% RDN through vermicompost + 50% RDN through urea at a spacing of 45×45 cm. The lowest seed yield was recorded in control (No fertilizers) (9.19 qha⁻¹) at a spacing of 60×45 cm.

S4 P65

Genotypic variability and therapeutic potential of fennel (*Foeniculum vulgare* Mill) seed extracts

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Fennel (*Foeniculum vulgare* Mill.) is an important seed spice known for its culinary and medicinal potential. Genetic variation in therapeutic properties of fennel seeds may be helpful in developing specific genotypes for medicinal point of view. Present study was conducted by taking pure seeds of five fennel genotypes of different geographical origin. Methanol and hexane seed extracts of fennel genotypes Ajmer Fennel-1, Gujarat Fennel-2, Hisar Swarup, Rajendra Saurabh, and Rajasthan Fennel-101 were used on albino mice as source of drug for evaluating its therapeutic properties. Both seed extracts were found to possess anti-inflammatory, anti-diabetic, hypolipidemic and antihypertensive properties, which varied significantly among the five genotypes. Present study indicated that both methanol and hexane seed extract of fennel genotype Rajendra Saurabha and Hisar Swarup possessed more anti-inflammatory properties while methanol extract of genotype Rajendra Saurabha showed slightly more anti diabetic activity. Hexane extract of genotype RF-101 produced significant hypolipidemic properties. This study validated the use of fennel extracts for treating various ailments and fennel as an important spice provided suitable genotypes are identified for a particular therapy.

S4 P66

Performance assessment of some fennel *Foeniculum vulgare* mill genotypes in central India

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Assessment of sixteen genotypes of fennel (*Foeniculum vulgare* Mill.) for growth, seed yield and its attributing characters during *Rabi* 2018-19 was conducted at Vegetable Research Centre, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The experiment was laid out in a Randomized Block Design with three replications. All the characters studied recorded wide range of variation among the genotypes. With reference to days to flowering it was observed that genotype FNL-124 was the earliest (85.33 days) which was at par with FNL-129 (88.67), FNL-125 (88.00 days) and FNL-128 (88.00 days). The genotype FNL-122 was reported to be late type which flowered in 100.67 days. The results revealed that significantly maximum plant height was recorded in genotype FNL-120 and proved to be the tallest (143.57 cm) followed by FNL-117 (139.45 cm). Minimum height was recorded in FNL-125 (118.87 cm). The overall mean height was 127.74 cm. The overall mean of number of branches per plant was recorded to be 5.17. Maximum number of branches (5.91) was observed in FNL-121 followed by FNL-120 (5.60) and FNL-119 (5.59). They were statistically at par with FNL-121. Minimum number of branches was recorded in genotype FNL-127 (4.6). The overall average was 15.60 while, genotype FNL-129 recorded the maximum number of umbels per plant (19.78) which was statistically at par with FNL-128 (18.07), FNL-121 (17.93) and FNL-119 (17.60). Minimum number of umbels per plant was observed in genotype FNL-123 (10.73). Total number of umbellets per umbel varied from 11.37 to 18.52. The overall average was 15.46. Maximum umbellets was recorded in genotype FNL-129. This was statistically at par with FNL-128 (18.23), FNL-121 (17.78) and FNL-119 (17.16). Minimum number was recorded by FNL-123 (11.37). Seed yield (q/ha) varied from 8.10-17.66q/ha. The overall average was 13.44 q/ha. FNL-129 was reported to be the highest yielder followed by FNL-118 (16.44 q/ha) and FNL-128 (15.97) which were also statistically at par. FNL-122 was found to be the poor yielder with 8.10 q/ha seed yield. The genotype FNL-129, FNL-118 and FNL-121 were found to be promising in respect of grower's preference.

S4 P67

Per se performance of ajowan (*Trachyspermum ammi* L.) genotypes for yield and physiological parameters

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The present investigation was conducted to study the *per se* performance of ajowan genotypes for yield and physiological parameter at HC & RI, TNAU, Periyakuam. Totally twenty genotypes of ajowan collected from different parts of India were evaluated under

field condition and the laboratory experiment was laid out in a Completely Randomized Block Design (CRBD) with three replications. Among the ajowan genotypes studied, significant level of variation was observed in chlorophyll 'a', chlorophyll 'b', total chlorophyll, chlorophyll stability index in all the three stages. The highest total chlorophyll content at vegetative stage (1.513), total chlorophyll content at flowering stage (2.874) and total chlorophyll content at fruit setting stage (0.914) was recorded by the genotype Acc. No.3. While, the lowest total chlorophyll content at vegetative stage (0.956), total chlorophyll content at flowering stage (1.160) and total chlorophyll content at fruit setting stage (0.445) were observed in Acc. No.11, in Acc. No.14 and LTa-26, respectively. The highest chlorophyll stability index at vegetative stage (76.04), chlorophyll stability index at flowering stage (83.80) and chlorophyll stability index at fruit setting (68.81) was recorded by the genotype Acc. No.3. Whereas, the genotype Acc. No.11, JA-110, JA-145 recorded the lowest chlorophyll stability index at vegetative stage (40.56), chlorophyll stability index at flowering stage (57.84) and chlorophyll stability index at fruit setting stage (34.08). The genotype Acc.No.3 has recorded the highest relative water content at vegetative stage (80.04), relative water content at flowering stage (82.80) and relative water content at fruit setting stage (74.24). While, the genotype LS- 1, JA-179, JA-186 recorded the lowest relative water content at vegetative stage (59.27), relative water content at flowering stage (61.42) and relative water content at fruit setting stage (50.58). The highest seed yield per plant was recorded by the genotype Acc. No.3 (38.83). It was followed by the genotype LTa-26 (35.21), LS-1 (32.61), GA-1 (32.54) and Acc. No.9 (30.14). Whereas, the genotype Acc. No.13 recorded the lowest seed yield per plant (15.13). The physiological parameters to significantly influence the higher seed yield per plant were observed in Acc. No.3 and it was followed by LTa-26, LS-1 and GA-1 of ajowan genotypes.

S4 P68

Performance of ajwain (*Trachyspermum ammi* L. Sprague) varieties at varying nitrogen levels on growth and yield under semiarid tropics of Northern Karnataka

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A field experiment was conducted at University of Horticultural Sciences, Bagalkot, Karnataka during *Kharif* season of 2016 and 2017 to find out the suitable varieties of ajwain (*Trachyspermum ammi* L. Sprague) at different nitrogen levels on growth and yield characters. The experiment was laid out with split plot design with three replications main plots consisted five varieties (Ajmer Ajwain-1, Ajmer Ajwain-93, Lam selection-1, Lam selection-2 and Local cultivar) and sub plots four nitrogen levels (50, 75, 100 and 125 kg/ha). The results revealed that growth and yield attributes were significantly higher in improved varieties compared to local cultivar. The highest plant height (81.82 and 80.56 cm), number of branches (52.36 and 50.98), plant spread (72.66 and 50.98 cm), number of umbels per plant (177.15 and 171.88), number of umbellates per umbel (11.81 and 11.65) and seed yield (14.44 and 14.26 q/ha, during both the years) was recorded in Ajmer Ajwain-1, which was *on par* with Lam selection-1 (13.93 and 13.56 q/ha, respectively). Application of nitrogen

up to 125 kg/ha significantly increased all the growth and yield attributes which was *on par* with 100 kg /ha. It is concluded that among the varieties Ajmer Ajwain-1 and Lam selection-1 found better with an optimum dose of 100 kg nitrogen per hectare.

S4 P69

Performance of ajwain (*Trachyspermum ammi* L.) genotypes for growth and seed yield

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Thirteen ajwain genotypes were evaluated for various plant growth, seed yield and essential oil content attributes during 2016-17 to 2018-2019 at six (Hissar, Guntur, Jobner, Jagudan & Faizabad) AICRP centres including ICAR-NRCSS, Ajmer, India. The significant differences were obtained for all the parameters studied. Plant height ranged from 118.8-121.1 cm, number of primary branches 18.0-18.8, umbels per plant 265.6-298.8, umbellate per umbel 24.0-27.4 and seeds umbellate 19.0-19.5. On the basis of mean seed yield (1652.45 kg/ha.) of three years (2016-17 to 2018-2019) at ICAR-NRCSS, Ajmer. Maximum seed yield was recorded as 1652.45 kg/ha in AA-73 followed by IA-1 (1406.91 kg/ha) showing an increase of 88.06 & 57.03% higher seed yield over Ajmer Ajwain-2 and Ajmer Ajwain-1 (checks), respectively. Seeds of AA-73 contains 9.15% total oil and 6.38% essential oil which is higher (39.26 and 17.27 percent, respectively) as compared to Ajmer Ajwain-2, national check. Based on the yield and quality performance Ajmer Ajwain-73 genotype can be recommend for commercial production of ajwain in India.

S4 P70

Yield and quality enhancement in ajwain (*Trachyspermum ammi* L.) through integrated nutrient management

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A trial was conducted on ajwain to promote the grain yield as well as essential oil yield by integrated nutrient management approach at College of Horticulture, Anantharajupeta, Y.S.R. Kadapa District, Andhra Pradesh. Farm yard manure and vermicompost were used as organic sources at 50% and 75% recommended dose of nitrogen (RDN). PGPRs namely *Azospirillum lipoferum*, *Bacillus megaterium* and *Frateuria aurantia* were used for seed priming. Micronutrients namely $ZnSO_4$ and Fe_2SO_4 were applied thrice as foliar application @ 0.5% first before flowering, second at 50% flowering and third during grain formation. The results revealed that highest number of umbels per plant, umbellets per umbel, number of fruits per umbellets, seed yield per plant, test weight of seeds, straw yield, biological yield, seed yield per hectare and essential oil yield were recorded with sole application of 50% RDN through VC which was on par with 50% RDN through FYM, seed priming with *Azospirillum* and foliar application of zinc. With respect to the quality attributes of essential oil of Ajwain, maximum essential oil content, fixed oil content and thymol content were observed by sole application of 50% RDN through VC, seed priming with *Azospirillum* and foliar application of zinc. In case of two-way interaction effects, application of 50% of

RDN through vermicompost along with seed priming with *Azospirillum* was found on par with 50% of RDN through FYM along with seed priming with *Azospirillum* in promoting high grain yield and its attributes. Significantly highest grain and essential oil yield were obtained with combined application of seed priming with *Azospirillum* along with foliar application of zinc. Further, all these yield attributing characters were also found significant with application of 50% of RDN through vermicompost along with foliar application of zinc and was found on par with 50% of RDN through FYM along with foliar application of zinc. However, essential oil yield and thymol content were significantly superior with application of 50% RDN through VC along with seed priming with *Azospirillum*. The combined effect of PGPR and micronutrient also found significantly superior with maximum essential oil content, essential oil yield, fixed oil content and thymol content by seed priming with *Azospirillum* combined with foliar application of zinc. The three-way interaction of organic manures, PGPRs and micronutrients could exert significant influence on yield and quality of ajwain. It was observed that the highest seed yield and essential oil yield and quality parameters were recorded with combined application of 50% of RDN through vermicompost along with seed priming with *Azospirillum* and foliar application of zinc which was statistically on par with application of 50% of RDN through FYM along with seed priming with *Azospirillum* and foliar application of zinc.

S4 P71

Effect of micro irrigation on yield and economics in fenugreek under various planting patterns

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A field study was conducted for three consecutive years during the *rabi* seasons of 2012-13, 2013-14 and 2014-15 at Agronomy Farm, S.K.N. College of Agriculture, Jobner (26 05' North latitude, 75 28' East longitude and at an altitude of 427 m above MSL) to select appropriate drip irrigation schedule for maximizing productivity of fenugreek and obtaining higher economic returns. The experiment comprised of nine treatments of irrigation levels and planting pattern *viz.* surface irrigation at 1.0 IW/CPE ratio with normal row planting, drip irrigation at 0.4, 0.6, 0.8 and 1.0 IW/CPE ratio with normal as well as paired row planting. The experiment was laid out in Randomized Block Design with three replications. The results revealed that drip irrigation at different IW/CPE ratios, except drip irrigation at 0.4 IW/CPE ratio with normal and paired row planting, significantly increased yield attributes and yields over surface irrigation at 1.0 IW/CPE ratio (control). Drip irrigation at an IW/CPE ratio 0.6 with paired row planting, being at par with 0.6 IW/CPE ratio in normal row planting and drip irrigation at 0.8 and 1.0 IW/CPE ratio in normal and paired row planting, recorded significantly higher plant height (103.07 cm), number of branches/plant (5.45), pods/plant (30.38), seeds/pod (16.60), pod length (12.03 cm), test weight (13.32 g), seed yield (18.77 q/ha), straw yield (47.27 q/ha), net returns (₹ 45952/ha) and B:C ratio (2.57) over 0.4 IW/CPE ratio with normal and paired row planting and surface irrigation at IW/CPE ratio 1.0. Further, drip irrigation at 0.6 IW/CPE ratio with paired row planting, remaining comparable to drip irrigation at 1.0 and 0.8 IW/CPE ratio, recorded higher yield increase

(49.3%) over surface irrigation at 1.0 IW/CPE ratio (control). Improvement in growth and yield attributes of fenugreek ultimately increased seed yield, irrigation water use efficiency and water saving. Thus drip irrigation systems out yielded the effect of surface irrigation.

S4 P72

Hisar Methi-425: A high yielding variety of fenugreek

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The present research work was carried out with the objective to develop high yielding variety of fenugreek suitable for leaf as well as seed production under Haryana condition, which resulted in the development of Hisar Methi-425 (HM-425), a high yielding variety, through pure line selection. This variety was tested for four years at Vegetable Research Farm, HAU, Hisar under Initial Evaluation Trial (IET) and further for three years in Coordinated Varietal Trial (CVT) at thirteen centers of AICRP on Spices. Fenugreek variety HM-425 recorded the highest yield of 29.72 and 20.52 q/ha under IET and CVT which was 24.90 and 14.64% higher over national check, respectively. It has also out yielded other varieties of different centres, Hisar Sonali & Rmt-361 (National checks) and local checks under Co-ordinated Varietal Trials at Hisar, Dholi, Raigarh, Kota, Jagudan & Ajmer centers and ranked 1st in overall mean yield over three years of all the 13 evaluating centers. This variety is suitable growing for leaf as well as seed purposes. It takes about 35-40 days after sowing for first cutting of leaves and 135-145 days for maturity as seed crop. Its seeds are of medium size with test weight of 15.0-16.0 g and bright yellow in colour. In view of its superior performance compared with national check varieties Hisar Sonali, Rmt-361 and other standard checks at Hisar and other co-ordinating centers and being less susceptible (14.8% incidence) to powdery mildew disease, this variety has been recommended for national release by XXIX Workshop/ Group meeting of AICRP on Spices held at Dr. Y.S. Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh during October 4-6, 2018. This new variety will boost fenugreek cultivation in the country.

S4 P73

Assessment of genetic variability, heritability and character association in Kalazeera [*Bunium persicum* (Bioss.) Fedts.]

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Kalazeera [*Bunium persicum* (Bioss.) Fedts.] is a high value herbaceous spice widely used for culinary, perfumery, medicinal and carminative purposes. It belongs to the family Umbellifereae (now called as Apiaceae) with chromosome number of $2n = 14$. It is a source of essential oils rich in terpenoids, phenylpropanoids, polyene and phototoxic furanocoumarins. The present investigation was carried out during *rabi* season of 2018-2019 at the Experimental Farm of Saffron Research Station, SKUAST-K, Pampore. The planting

material for the present investigation comprised of 22 genotypes including check selected from the germplasm resources maintained at Advanced Research Station for Saffron and Seed Spices, SKUAST-K, Pampore. The experiment was laid out in a randomized block design with three replications. Results of the study revealed significant differences for all traits except 1000-seed weight which showed non-significant variation. Phenotypic coefficients of variation were greater in magnitude over the respective genotypic coefficient of variation. High to moderate heritability coupled with high genetic advance was noticed for umbels plant⁻¹ and seeds umbel⁻¹ which provided the evidence that these traits were under the control of additive genetic effects, while rest of the traits exhibited variable trends. Seed yield (g m²) was significantly and positively associated with all the studied traits except for biological yield at both phenotypic and genotypic levels. Hence, it was observed that indigenous accessions have great proportion of genetic variability, which can be manipulated in future breeding programs to fully utilize their genetic potential.

S4 P74

Seed priming: An innovative way to improve germination and viability of seed spices

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Seed priming is an innovative seed treatment method and the process of control the hydration of seeds. Seed priming is useful to increase the speed of seed germination and uniformity of germination particularly under unfavorable conditions like temperature, moisture and salinity. Seeds are soaked in different solutions like various inorganic salts, sugars and polyethylene glycol, a chemically inert, high molecular weight compound, some bio-priming agents (*liquid Azospirillum* and phosphobacteria) etc. After seed priming, increase in hydrolytic enzyme activity especially α -amylase, catalase activities and expression of certain proteins related to water stress and heat stress are observed. During germination the primed seeds contain higher scavenging of Reactive Oxygen Species (ROS). The primed spice seeds or rhizomes contain abiotic stress tolerant capacities, increase the antioxidant enzyme activities like peroxidase, catalase, superoxide dismutase, polyphenol oxidase, lipoxygenase and phenyl alanine ammonia lyase, break the seed dormancy, enhance the germination percentage and early growth. With the use of seed priming we can increase viability and germination percentage of different seed spices like cumin, fennel, dill, etc.

S4 P75

Performance evaluation of garlic (*Allium sativum* L.) accessions for high yield under Nilgiris condition

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Seventy-two accessions of garlic were evaluated during 2015-2016, 2016-2017 and 2017-2018 at Nanjanad farm, Horticultural Research Station, Ooty. Among 72 accessions, 22 accessions were collected from all over India through All India Network Project on Onion

and Garlic scheme and rest of the collections were made from different parts/villages from Nilgiri District of Tamil Nadu. The accessions collected were planted in a randomized block design with three replications. The net plot area was 2 m² (1 x 2 m²). Observations were taken on growth and yield characters. The result revealed that the highest plant height of 74.53 cm was observed in As72 followed by As29 (71.27 cm) while the lowest value was found in As66 (46.47 cm). The equatorial diameter and polar diameter value of 41.88 mm and 46.99 mm, respectively, were found to be the highest in As72. Similarly, As 72 recorded the highest bulb weight (41.60 g) followed by As 11 (39.26 g) and As 4 (37.05 g) and 10 clove weight (29.50 g) whereas the lowest clove weight was observed in As 57 (11.50 g). Among the 72 accessions, As 72 recorded the highest yield per plot (5.13 kg), yield per ha of 129.3 q/ha and marketable yield of 141.1 q/ha while the lowest yield per plot (2.17), yield per hectare (45.3 q/ha) and marketable yield (56.4 q/ha) was found in As 17. The characters *viz.*, 10 clove weight, average bulb weight, equatorial and polar diameters of bulb and yield per plot are most important yield related characters for selecting best genotype for specific location. Based on this study, As 72 was the best performing accession and it can be taken for further study to improve yield, quality and storage which can lead to sustainable cultivation of garlic under Nilgiris condition.

S4 P76

Response of integrated nutrient management on the growth, yield and quality of Kharif onion (*Allium cepa* L.)

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This field experiment was conducted in a farmer's field at Trichy during 2019. The experiment comprised of 8 fertility levels (Control, 75%, 100% and 125%), recommended dose of NPK, vermicompost 2.5 t ha⁻¹ with 25 per cent, 50 per cent and 75 per cent recommended dose of NPK. The application of 50 per cent recommended dose of NPK + vermicompost 2.5 t ha⁻¹ significantly improved the plant height, number of leaves at harvest, equatorial diameter thickness of scale, volume of bulb, yield and TSS, vitamin "C" and allyl propyl disulphide content.

S4 P77

Studies on evaluation of aggregatum onion (*Allium cepa* var. *aggregatum*) for high yield under Tamil Nadu conditions

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An experiment was conducted at College Orchard of Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2015-2016, 2016-2017 and 2017-2018 to evaluate 55 aggregatum onion (*Allium cepa* var. *aggregatum*) accessions for high yield and quality. Among the 55 aggregatum accessions evaluated, significant variations were observed for all the traits *viz.*, plant height (cm), leaves per plant, polar and equatorial diameter of bulbs (mm), average clump weight (g), total yield (t/ha) total soluble solids (°brix) thrips damage (%) and leaf spot incidence (PDI) in three experiments. The result revealed that the highest plant height

of 48.2 cm and number of leaves of 35.3 was observed in the accession Aca 15. Similarly, the accession Aca 15 recorded the highest average clump weight (97.70 g) followed by Aca 9 (98.0 g) while the lowest average clump weight of 55.2 g and 56.3 g was observed in Aca 46 and Aca 48, respectively. Among the 55 accessions evaluated, the highest total yield was observed in Aca 15 (22.93 t/ha) followed by Aca 9 (21.13 t/ha) while the least value of 9.4 t/ha was found in Aca 46 and TSS of Aca 15 recorded average value of 18.3 per cent during three experiments. Onion is most sensitive to thrips feeding injury when plants are young and when bulbs are rapidly enlarging. Hence, among these accessions the lesser incidence of thrips damage was observed in the accession Aca 15 (8.33 per cent) followed by Aca 5 (9.93 per cent). Considering yield and yield related characters, aggregatum onion Aca 15 can be selected as the best accessions for South Indian conditions. Therefore, findings of the present study will help scientists for further yield improvement in aggregatum onion.

S4 P78

Studies on canopy management in curry leaf (*Murraya koenigii* Spreng.)

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To find out the optimum height of pruning, harvest interval and the response of plant to application of nutrients and cultural practices on growth and yield of curry leaf, an experiment was conducted at Department of Spices and Plantation Crops, HC & RI, Periyakulam during 2014 and 2015. A total of 16 treatments comprising of three factors with pruning heights (two levels- 15 cm, 30 cm) harvest intervals (two levels- two months, three months) and foliar application of nutrients (four levels - zinc sulphate, ferrous sulphate, sea weed extract and humic acid) under split plot design with three replications. The results of the study revealed that pruning height, harvest interval and foliar application of nutrient had significant effect on yield and quality of fresh curry leaf. The individual effect of all the three factors of the study revealed that growth, yield and quality of curry leaf had significantly enhanced the morphological, physiological and biochemical traits of curry leaf. The interactions of the three factors showed that fresh curry leaf yield and quality characters could be improved by adopting 30 cm pruning height at three months' interval of harvest and application of 0.3 per cent humic acid which was also found to be economical.

S4 P79

Studies on the effect of iron and zinc application for growth and yield of curry leaf (*Murraya koenigii* Spreng)

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The study was carried out at Horticultural College and Research Institute, TNAU, Coimbatore during 2019 to study the role of micronutrients in enhancing the leaf yield of the crop. The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatment consisted of two micronutrients of iron and zinc applied as ferrous sulphate and zinc sulphate applied as soil (25 kg/ha, 12.5 kg/ha) as well as foliar

(0.5%, 0.25%) applications with spraying intervals of 30 and 45 days and FYM application at 20 t/ha. Application of ferrous sulphate positively influenced the morphological parameters such as plant height (236.08 cm and 271.41 cm), leaf length (3.78 cm and 4.84 cm), leaf width (3.18 cm and 3.68 cm), no. of rachis/shoots (14.16 and 16.3), no. of shoots/plant (12.87 and 13.50) as well as yield parameters namely leaf yield per plant (0.99 kg and 1.05 kg) and estimated leaf yield/ha (9933.33 kg and 10100 kg). Foliar application of 0.5% ferrous sulphate significantly influenced the quality parameters of curry leaf in season I and II *viz.*, ascorbic acid (3.80 mg/100g and 3.90 mg/100g), soluble protein (8.81 mg/g and 9.91 mg/g), proline (278.32 $\mu\text{g/g}$ and 295.01 $\mu\text{g/g}$) and Nitrate reductase activity (398.35 $\mu\text{g NO}_2/\text{g/hr}$ and 410.45 $\mu\text{g NO}_2/\text{g/hr}$). Spraying of 0.5 % ferrous sulphate showed highest essential oil content (0.25% and 0.29%) and oleoresin content (33.24% and 39.24%) in curry leaves. Soil application of 25 kg/ha ferrous sulphate significantly influenced the N, P, K, Fe and Zn content *viz.*, N (198.31% and 204.40%), P (22.00% and 18%) and K (59.37% and 54.79%), Fe (1.26% and 1.90%) and soil application of ZnSO_4 significantly increased the Zn (5.64 mg/kg and 5.89 mg/kg) in both seasons. The application of ferrous sulphate 0.5% significantly influenced the N, P, K, Fe and Zn uptake *viz.*, N (75.89% and 86.00%), P (16.90% and 16.35%) and K (59.37% and 61.34%), Fe (1.59% and 1.96%) and foliar application of ZnSO_4 significantly increased Zn (0.29 mg/kg and 0.31 mg/kg) in both season, respectively. From this study, it can be concluded that foliar application of ferrous sulphate 0.5% was best for increasing yield, quality and essential oil content in curry leaf. Direct supply of nutrients to leaves enhanced the physiological activity. Soil application showed lower beneficial effects and hence, foliar application was better than soil applications.

S4 P80

Density and corm weight effects on stigma and corm yield in saffron (*Crocus sativus* L.) production

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A study was initiated in 2017 to develop profitable production system module at Advanced Research Station for Saffron and Seed Spices, Pampore SKUAST-Kashmir to determine a suitable planting density and corm weight for saffron, involving 6 densities *viz.*: 18 lakh corm density/ha, 15 lakh corm density/ha, 12 lakh corm density/ha, 10 lakh corm density/ha, 05 lakh corm density/ha and 03 lakh corm density/ha (farmers practice) and two corm sizes based on the corm weight in two levels ($W_1 = 6-7$ g and $W_2 = >7$ g). Except farmers practice, saffron corms were planted in ditches of diverse plant geometry to accommodate 05 unlike densities. Traits including plant emergence percentage, number of plants and flowers per unit area, length of rod, length of stigma, fresh and dry weight of flowers, fresh and dry weight of stigmas, total stigma yield, corm multiplication ratio, the onset of flowering and flowering period were evaluated on the plants. Results showed that all above mentioned traits except length of rod were significantly affected by planting density and corm weight. Flowering of bigger corms initiated earlier and their flowering period was more than others. Evaluation over 4 years confirmed distinct yield superiority by planting corms >7 g with plant population of 12 lakh corms/ha on raised bed fetch returns

to the tune of ₹ 1,05,03,000 on account sale of 47.52 kg saffron/ha and 250 quintals of corms/ha with B:C ratio of 4.28:1 over a period of 4 years.

S4 P81

Evaluation of saffron clones for higher yield and quality

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Saffron (*Crocus sativus* L.) is the most expensive spice in the world known for its flavouring, medicinal and pharmaceutical properties. It is triploid ($3x=2n=24$) geophytes perennial in nature, belongs to family Iridaceae. Owing to triploid nature, it allows only vegetative multiplication and provides very little probability of crop improvements through conventional breeding methods. There is no sexual reproduction owing to meiotic abnormalities which results in abnormal chromosome assortment. Utilization of variation in natural population accumulated over the period since centuries in centre of origin and domestication which is attributable to genetic and environmental factors are imperative for its improvement. Further, the corm multiplication rate is very slow and requires 4-5 years to produce flowering size corm. Therefore, there is need to identify genotypes with increased flower numbers per corm, flower colour, fresh flower weight and size, stigma fresh and dry weight, corm multiplication rate etc. Through intensive survey of saffron growing areas of Kashmir Valley as many as 232 superior saffron clones / genotypes were collected and planted under uniform growing condition at Research Farm of Advanced Research Station for Saffron and Seed Spices, SKUAST-Kashmir. Out of these, 32 clones were finally evaluated for yield and quality attributes and identified ten best clones namely SRS-125, SRS-123, SRS-124, SRS-122, SRS-12, SRS-121, SRS-107, SRS-120, SRS-104 and SRS-117 with high saffron yield (3.5 to 4.5 kg/ha) and associated traits like stigma size and weight in their initial planting years as against average productivity of 2.3 kg/ha and are expected to yield 7-8 kg/ha after 4-5 years. The evaluation and further multiplication of these elite clones are under progress.

S4 P82

Influence of integrated nutrient management on stigma and corm yield of saffron (*Crocus sativus* L.)

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In order to evaluate the effect of nutrient application from integrated nutrient management (INM) sources on saffron, a field experiment was conducted on silt clay soil at Advanced Research Station for Saffron and Seed Spices, Pampore SKUAST-K during *khraif* season 2015-18 to evaluate the response of integrated nutrient management on stigma and corm yield of saffron (*Crocus sativus* L.). The experiment was conducted in factorial randomized

block design with three replications. The levels of fertilizers were 90, 120, and 150 kg ha⁻¹ of nitrogen; 10, 15, and 20 tons ha⁻¹ of farm yard manure (FYM), and 05 and 10 quintal ha⁻¹ of vermicompost. Evaluation over four years confirmed that saffron responded to organic manures when used in integration with inorganic fertilizers. Application of 120 kg N ha⁻¹ in conjunction with 15 t farmyard manure (FYM) ha⁻¹ plus vermicompost 10 quintal recorded highest stigma yield and exhibited 57% increase over control. The combined application of fertilizer N, FYM and vermicompost sustained the productivity even at lower rate of fertilizer N application. Moreover, the soil organic carbon, available N, P and K content increased with the application of fertilizer N, P and K alone and in conjunction with organics (FYM, vermicompost) compared with control. INM module with plant population load of 12 lakh corms ha⁻¹ fetch returns to the tune of ₹1,02,05,345 on account yield of 41.32 kg saffron ha⁻¹ and 242 quintals of corms ha⁻¹ over a period of four years. Average productivity of 10.95 kg ha⁻¹ was observed when Nitrogen 120 kg, FYM 15 tons and vermicompost 10 quintal was applied ha⁻¹. FYM and vermicompost application significantly increased both flower yield and corm production thus it can be effectively used as an alternative for application of FYM which presently is unavailable and if available is very costly. Moreover, given years, the use of integrated nutrient management module earned maximum benefit cost ratio of 4.15:1. Conclusively, INM module might be a better technique over separate application of inorganic source.

S4 P83

Study on irradiation (gamma rays) and temperature treatments on corm multiplication and floral traits of saffron (*Crocus sativus* L.)

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Corms of saffron obtained from germplasm bank of Saffron Research Station, SKUAST-Kashmir Pampore were used in the present investigation. The experiment was categorized into three treatment groups i.e. gamma rays, heat treatment and cold treatment. In the first category corms were exposed to 1.0 (T₁), 2.0 (T₂), 3.0 (T₃), 4.0 (T₄) and 5.0 (T₅) kR of gamma rays at BARC, Zakoora, Srinagar. In the second category the corms were subjected to heat treatment viz., 35°C for 24 h, 16 h light period and 8 h dark period (T₆), 35°C for 24 h, complete light (T₇) and 35°C for 24 h complete dark (T₈) and in the third category corms were subjected to cold treatments viz., 4°C for 24 h, 16 h light period and 8 h dark period (T₉), 4°C for 24 h, complete light (T₁₀), 4°C for 24 h, complete dark (T₁₁) along with untreated control (T₁₂). The experiment was conducted at Research Farm of Advanced Research Station for Saffron and Seed Spices, SKUAST-Kashmir, Pampore in single plot design. The results indicated that a reduction in the germination percent over control was noticed in all the gamma rays treatments. In general, reduction in germination percent was associated with the increase in the dose of the mutagen. The LD₅₀ was found to lie between 4.0 kR and 5.0 kR of gamma rays. In case of quantitative traits, T₉ (197.25 mg) showed higher dry pistil weight/plot which was followed by T₁₀ (184.20 mg) and T₆ (173.14) while the lowest dry pistil weight/plot was recorded for treatment T₅ (67.89 mg). The control treatment T₁₂ showed the dry pistil weight/plot of 160.74 mg.

S4 P84

Effect of mulching and nutrient management on yield and quality of sweet basil (*Ocimum basilicum* L.)

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A field experiment was carried out at College of Horticulture, UHS Campus, Bengaluru during October 2018 to January 2019 to study the influence of mulches and nutrition on yield and quality of sweet basil (*Ocimum basilicum* L.). Sixteen treatment combinations with three replications were adopted in a factorial randomized complete block design. Four different mulches (no mulch, black plastic mulch, silver plastic mulch and organic mulch) each combined with different levels of nutrition (100 per cent RDF, combination of 75 per cent RDF and humic acid, 75 per cent RDF and microbial consortia and 75 per cent RDF, humic acid and microbial consortia) were used. Among the mulches, use of black mulch has resulted in maximum fresh yield (24.55 t ha⁻¹), dry yield (8.72 t ha⁻¹), essential oil content (1.13 %) and essential oil yield (97.21 kg ha⁻¹). Among different levels of nutrition, application of 75 per cent RDF with microbial consortia recorded maximum dry herbage yield (7.27 t ha⁻¹), while 75 per cent RDF with humic acid has resulted in maximum essential oil content (1.21 %). Maximum essential oil yield (79.03 kg ha⁻¹) was recorded with the application of 75 per cent RDF, humic acid and microbial consortia. Among interaction, black mulch combined with 75 per cent RDF and humic acid have resulted in maximum essential oil content (1.44%) and essential oil yield (109.92 kg ha⁻¹). The highest methyl chavicol content (73.85%) was observed in plants grown with black mulch with application of 75 per cent RDF and microbial consortia.

S4 P85

Exploring wild relatives of spices from Andaman & Nicobar Islands

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Andaman & Nicobar Islands, one of the largest archipelagos in the Bay of Bengal, consist of 572 islands and islets situated between 6°45' -13° 41'N and 92° 12' - 92°57'E. Humid tropical climate and large forest cover made the Islands as the part of two biodiversity hotspots with several endemic species. Flora of these Islands shows affinities with that of Myanmar, Thailand and Indonesia. Surveys were conducted to various islands of Andaman and Nicobar during 2019 and 2020 to collect and conserve crop wild relatives. A total of 162 accessions of wild relatives of tropical spices belonging to seven families were collected and conserved in the germplasm repository at ICAR-IISR, Kozhikode, ICAR-NBPGR Regional Station, Thrissur and ICAR-CIARI, Port Blair. The collection comprises of seven species of *Piper*; eight of *Zingiber*, six of *Curcuma*, three each of *Alpinia*, *Amomum* and *Etilingera*, one each of *Plagiostachys* and *Kaempferia*; seven of *Garcinia*; two of *Cinnamomum*;

five of *Syzygium*; one each of *Myristica*, and *Horsfieldia*; two of *Knema* and two of *Vanilla*. The collection includes five species endemic to the Islands. *Piper wallichii*, *P. clypeatum*, *Curcuma roscoeana*, *Zingiber odoriferum*, *Myristica andamanica* *Garcinia andamanica* and *G. dhanikhariensis* are some of interesting species encountered during the exploration. Apart from the use as gene pool for breeding programmes, some of the species has direct potential as spice/fruit/medicine/ornamental/rootstock. Since the ecosystems of the Islands are highly prone to natural calamities and vulnerable to alien invasive species/developmental activities, collection and *ex situ* conservation is a matter of great importance.

S4 P86

Macro and micro propagation in *Embelia ribes* Burm.f: A threatened species

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Embelia ribes Burm.f or *Vidanga*, a red listed medicinal plant belonging to family Myrsinaceae is one of the 32 medicinal plants selected for large scale cultivation by National Medicinal Plants Board, New Delhi. Vegetative propagation studies using stem cuttings and nodal explants were undertaken at ICAR-Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru. Semi hardwood stem cuttings were treated with Indole Butyric Acid and Naphthalene Acetic Acid in different concentrations. Different growth parameters like number of sprouts per cutting, length of the shoot and number of leaves per cutting were highly influenced by IBA 3000 ppm. Micropropagation was carried out to develop a multiplication protocol using matured nodal segment as explant cultured on MS medium supplemented with various combinations of hormones. Out of the six growth regulator treatments given to the nodal segments better results for shoot length, number of shoots per explants and number of leaves per plant were recorded in MS medium supplemented with BAP (0.50 mg/l) and IAA (0.01 mg/l). Even though vegetative growth parameters were promising, rooting was not observed and it might be due to the secondary metabolites, endogenous plant growth regulator level in the plant tissue which varies with organ, genotype or the phase of the plant growth.

SESSION V



Spices – Environment and food safety

ORAL PRESENTATION

S5 OP1

Influence of altitude and management practices on yield of black pepper in high altitude and misty area in Kodagu District, KarnatakaS J Ankegowda¹, M Alagupalamuthirsolai² & K S Krishnamurthy²¹ICAR-Indian Institute of Spices Research, Regional Station, Appangala-571201, Karnataka, India²ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala, India

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The experiment was conducted in farmer's field at Surya Kiron estate in Hattihole, Somwarpet located at different altitudes ranging from 891 MSL (2923 ft) to 1168 MSL (3832 ft). Black pepper vines grown around 1040 MSL (3412 ft) and above were not producing good crops even though flowering occurred during July-August and all the spikes dropped due to anthracnose disease and lack of bisexual flowers. To initiate flowering in May, shade regulation during February followed by sprinkler and hose irrigations (from March 10 at 10-15 days interval) were undertaken which resulted in flowering and fruit setting during May-June. Spike shedding was almost controlled with prophylactic sprays with Carbendazim 2 g/litre in April and 1% Bordeaux mixture in May. Spiking intensity was recorded at 891, 912, 926, 938, 962, 979, 1018, 1030, 1040, 1078, 1087, 1100 and 1168 MSL. The number of spikes per m² ranged from 30.75 (1087 MSL) to 59 (891MSL) with a mean of 40.73. The spike length (cm) ranged from 10.64 (926 MSL) to 17.4 (1018 MSL) with a mean of 13.36. The number of berries per spike ranged from 51.8 (926 MSL) to 84.7 (1078 MSL) with a mean of 71.4. The data clearly indicated that, black pepper can be grown at higher altitude (1078 MSL; 3536 feet) adopting early shade regulation and irrigation. The quality and gas exchange parameters recorded at different altitudes did not record significant variation.

S5 OP2

Are soil available nutrient pools varying by patch (field) scale in Indian cardamom hills?Muthusamy Murugan^{1*}, M K Dhanya, Alappan Subbiah², Ashokkumar Kaliyaperumal¹ & Nimisha Mathew¹¹Cardamom Research Station, Kerala Agricultural University, Pampadumpara-685553, Idukki, Kerala, India²Grapes Research Station, Tamil Nadu Agricultural University, Anamalayanpatty-625526, Theni, Tamil Nadu, India

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In this study, we report and explain patch scale (slope and forest features) variations in the soil available nutrient pools as well as other physical and biological parameters that are pertinent for site-specific fertilizer and nutrient management programme. The Indian cardamom hills are recognized universally as the primary home for small cardamom, which is one of the very ancient spices in the world. The lands in the cardamom hills have been put into use for continuous cultivation of cardamom since many centuries. Predominantly, the soils in these mountains belong to the order "Ultisols" and they were originally acidic and less fertile owing to high annual rainfall, steep slope, salts and nutrient leaching as well as accumulation of nutrients in the forest biomass. Surface soils (15-20 cm) were sampled from the lowest, middle and highest points in a moderately steep sloppy

(20-30% slope) cardamom fields. Soil samples from underneath dominant tree species as well as farmer's fields and open areas were collected and subjected for analysis for key soil physico-chemical and biological parameters. The concentration of micro elements were quantified by AAS (Perkin Elmer). Soil samples were collected from the farmer's fields as well as research farm of the Cardamom Research Station, Pampadumpara and analyzed during the previous season. Results of the soil analysis showed considerable changes in the ecosystem processes including variations in the soil acidity, organic carbon content and soil available nutrients. Forest composition had significant influence on the biological load and diversity primarily of soil bacteria and actinomycetes as well as dehydrogenase activity in soil. Greater concentration and accumulation of available soil nutrients like phosphorus, calcium, magnesium, manganese and copper have been noticed depending on the slope and forest characters. Soil physical parameters varied insignificantly across the point of slope. Survey of tree species composition showed increased trend of introduced tree species (*Vernonia arborea*, *Toona ciliata* and *Artocarpus heterophyllus*), accounting more than 50% of the total tree stand. Nearly, 40 years after clear felling of forest trees at the station, the soil pH of the site has increased by one unit (from 5.5 to 6.5) while the soil organic carbon (SOC) reduced to 1.7% from 2.2% and nitrogen level drastically down to 0.5% from 1.3%.

S5 OP3

Current scenario of diseases of nutmeg in Kerala and the ways to tackle the challenge

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In order to document all major diseases infecting nutmeg grown in Kerala, purposive sampling surveys were conducted in the farmer's fields. The major diseases recorded were *viz.*, leaf spots/anthracnose, leaf blight and leaf fall, fruit fall and thread blight. The key diagnostic symptoms of each disease were also documented. The *in vitro* efficacy of bioagents *viz.*, *Trichoderma* and *Pseudomonas fluorescens* and the efficacy of chemical fungicides *viz.*, Tebuconazole, Azoxystrobin, Copper hydroxide, Bordeaux mixture and the combination product, Mancozeb + Cymoxanil were also assessed against the major pathogens of nutmeg *viz.*, *Phytophthora* sp., *Colletotrichum* sp., *Cylindrocladium* sp., *Pestalotiopsis* sp., *Marasmius* sp., *Lasioidiplodia* sp. and *Phomopsis* sp. *Trichoderma* resulted in more than 80% reduction of growth of all the pathogens except *Lasioidiplodia* sp. and *Marasmius* sp. It recorded cent per cent inhibition of *Phytophthora* sp. *Pseudomonas fluorescens* recorded more than 50% reduction on the growth of pathogens except *Phytophthora* sp. which showed only 16.67% reduction. Bordeaux mixture and Tebuconazole recorded cent per cent inhibition on the growth of all the fungal pathogens of nutmeg. Copper hydroxide also showed cent per cent inhibition of all pathogens except *Lasioidiplodia* sp. in which it recorded 85.19% reduction. Azoxystrobin recorded cent per cent inhibition of three pathogens *viz.*, *Pestalotiopsis* sp., *Marasmius* sp. and *Phomopsis* sp. It recorded only 27.78% inhibition of *Phytophthora* sp. Mancozeb + Cymoxanil showed cent per cent inhibition on the growth of only two pathogens *viz.*, *Phytophthora* sp. and *Pestalotiopsis* sp. A sustainable management package of recommendations was also developed to control the diseases of nutmeg. Field evaluation of selected fungicides showed that, copper hydroxide (Kocide 0.2%) and Bordeaux mixture (1%) were the best fungicides for the management of various leaf spot

diseases, anthracnose, leaf blight and fruit fall diseases of nutmeg. The field evaluation also revealed the efficiency of Tebuconazole (0.1%) which showed the highest reduction in the incidence of anthracnose and various leaf spot diseases. Soil application of *Trichoderma viride* enriched in cowdung and neem cake along with Copper hydroxide (0.2%) foliar spraying can be recommended for the management of fruit diseases of nutmeg. Foliar sprays with Copper hydroxide (0.2%) or Bordeaux mixture (1%) along with soil application of *Trichoderma viride* enriched in cowdung and neem cake@10 kg/tree can be recommended for the management of dieback disease complex in nutmeg.

S5 OP4

Modified Atmospheric Packaging (MAP) for management of Cigarette beetle (*Lasioderma serricornis*) in ajwain and cumin seeds

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Seed spices are generally stored for a year or more at farmer's level. Association of storage insect pests with seed spices are well documented. In most cases insect infestation come from field and other sources is the store house. The insect infestation generally remains undetected until adults are seen. By the time these adults are detected, much of seed are already damaged. The cigarette beetle *Lasioderma serricornis* is the most dangerous causing maximum damage to most of the seed spices during storage. Experiment on Modified Atmospheric Packaging (MAP) using different inert gases alone and in combination with seeds of ajwain (*Trachyspermum ammi*) and cumin (*Cuminum cyminum*) evaluated for management of cigarette beetle and other quality parameters. The results showed that, all the inert gases caused complete mortality of the beetle both at room temperature and controlled environment. Oil content estimated after 120 days showed that in ajwain seeds, the maximum total oil content was found in seeds packed with O₂ alone and the maximum essential oil in ajwain seeds of vacuum packaging in both environments. Microbial load on ajwain showed the minimum fungal count observed in seeds packed with O₂ and bacterial count in CO₂ (50%) +N₂ (50%) at room temperature and was at par with vacuum at controlled temperature. In cumin seed, total oil content was observed maximum in seeds packed with CO₂ both in room and controlled temperature, whereas essential oil was maximum in seeds packed with N₂ at room temperature and CO₂ (50%) + O₂ (50%) at controlled temperature. Vacuum packaging of cumin seeds showed minimum fungal and bacterial count both in the seeds kept at room temperature and controlled environment.

S5 OP5

Diversity, abundance, foraging behaviour of insect pollinators and impact of mode of pollination on coriander (*Coriandrum sativum* L.)

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Biodiversity of insect pollinators on coriander (*Coriandrum sativum*) cv. DH 246 and cv. DH 228 was studied under agro-ecological conditions of Hisar, Haryana, India. Thirty insect species belonging to fifteen families of five orders were recorded from coriander

flowers in which, ten belonged to order Lepidoptera, ten to Hymenoptera, six to Diptera, three to Coleoptera and one to Odonata. Among the insect pollinators, honey bees *viz.*, *Apisflorea*, *Apiscerana indica*, *Apismellifera* and *Apis dorsata* were the most frequent visitors of flowers of coriander. Among different bee species, the maximum mean population observed in case of *A. floreae* (6.81 and 6.92 bees/m²/5 min), whereas, the least abundance was observed in case of *A. cerana* (2.01 and 2.03 bees/m²/5 min) on coriander cv. DH 246 and cv. DH 228, respectively. The pollination index of *A. dorsata* was highest (27094658 and 32348606) followed by *A. mellifera* (18261555 and 19182874), *A. florea* (10264032 and 9625582) and *Apiscerana* (6415880 and 7231022) on coriander flowers of cv. DH 246 and cv. DH 228, respectively. Hence, *A. dorsata* was the most efficient pollinator followed by *A. mellifera*, *A. florea* and *A. cerana*. All the four bee species were found to be top workers while foraging on coriander flowers. *A. floreae* and *A. dorsata* initiated foraging activity little earlier in the morning, whereas *A. floreae* and *A. mellifera* ceased their activity little later in the evening. *A. florea* spent maximum time 4.48 and 3.81 sec/umbellate while, *A. dorsata* spent minimum time 1.23 and 1.13 sec/umbellate on coriander cv. DH246 and DH228, respectively. *A. dorsata* visited the maximum (23.57 and 23.44) number of umbellate per minute while, *Apisflorea* visited least number (7.85 and 7.17) of umbellate per minute on coriander cv. DH246 and DH228, respectively. *Apis dorsata* entrapped the highest number of loose pollen grains (294000 and 306000) followed by *A. mellifera* (256000 and 264000) and *A. cerana* (242000 and 246000) and was lowest in case of *A. florea* (192000 and 194000) while, foraging on coriander flowers cv. DH246 and DH228, respectively. The yield/plant (18.58 and 17.48 g), yield/m² (183.4 and 173.66 g), test weight (17.24 and 14.36 g) and per cent germination (76.4 and 82) were significantly higher in case of open pollination as compared to without insect pollination (13.48 and 12.84 g), (134.62 and 128.64 g), (13.04 and 10.92 g) and (58.8 and 61%), respectively in coriander cv. DH 246 and cv. DH 228. The activity of different bee species on coriander varied with different abiotic factors and had significantly positive correlation with bright sunshine hours (BSS) and temperature (TEMP) in different hours of the day during foraging but had negative correlation with relative humidity (RH). It is observed that, the effect of wind velocity on foraging of different bee species was not significant. Thus the impact of abiotic factors might decide the foraging activity of different insect pollinators.

S5 OP6

Cumin (*Cuminum cyminum* L.) pollination behavior: A case study

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Generally, cumin being a plant of *Apiaceae* family is considered to be open pollinated in nature. Studies on the extent of natural cross pollination (NCP) in the crop are meager. Breeding behaviour of cumin is indecisive, thus an experiment taking four morphotypes varying for flowering duration, flower colour and plant type was carried out to know the extent of cross pollination. The morphotypes selected were CAZRI cumin 94 (CZC94-early flowering i.e. in 40 days), CZC96 (white flower bushy plant type), CZC64 (light pink flower erect plant type) and CZC78 (pink flower erect type plant with high biomass). A minimum of 400 plants for each morphotype were studied over two generations i.e. in 2018 under

plant to row trial minimum 75 plants for each were observed and in 2019 under row to plot trial minimum 325 plants for each were observed. No differences were observed among the population of the morphotypes for deviation from the genotype specific phenotypic marker trait thus suggesting prevalence of self-pollination in cumin. The present study suggested the occurrence of self-pollination in cumin. The morphotypes selected in the study were natural variants which appeared in the GC4 population in very low frequency thus reflecting occurrence of very low natural recombination or mutation in the crop. The finding supports no anemophily behaviour in the crop, thus chance of out crossing in cumin is very minimum. Hence, pureline breeding can be practiced effectively in cumin for developing genetic stock, available natural variants can be collected and evaluated for development of better cultivars.

S5 OP7

Spice clinic: Going public to provide plant health management services for farmers

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Spice clinics are aimed to diagnose plant health problems, provide reliable advice on control and strengthen community-based disease and pest surveillance. The clinics commenced its activities in 2009-10 and are usually organized jointly by Research and Development Departments of Spices Board in association with spice producer's associations in a locality or other stakeholders requiring advisory services. Each clinic is one day long public programme that provide plant health advisory services for small, medium and large holders which is also an extension method helped to reach the unreached to solve integrated crop production and protection issues in the critical stages of crop growth. In the morning session, a team of crop protection and crop management specialists visited 7-8 spice farms and diagnosed plant health issues reported by the farmers. The specialists gave on-site recommendations to specific problems and representative plant samples with symptoms were collected for display and education later in the day. In the afternoon session, the subject specialists and 20-25 farmers were assembled in one selected field or house premises and the problems noticed during the field visits were described and control measures suggested. During 2019-20, fourteen spice clinics were organized in different cardamom growing areas of Idukki, Kerala. Fifty six farms were visited for on-site diagnosis of plant health problems and 251 farmers participated in the learning session. The clinic provided diagnosis and advice on any problem and any spice crop including black pepper, vanilla, nutmeg, clove, ginger, turmeric etc. When additional tests were required, soil and plant samples were brought to the laboratory for confirmation of deficiencies, pests and pathogens. Spice clinics are ideal for sharing knowledge about farming within local communities and also serve as a gateway where policy makers can collect important data enabling decision making. The farmers were able to consult an objective advisor on how to protect and manage the spice crops. Not surprisingly, however, many inadequacies like lack of advanced mobile lab for examination of specimens on the spot still need to be addressed so that clinics can fully play their part in providing plant protection services at grass root level. Success and constraint indicators in the diagnostic performance of the clinics are to be further identified and addressed.

SESSION V



DIGITAL POSTER PRESENTATION

S5 P1

Crop modelling in black pepper

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In the present study, a regression model was developed to predict productivity of black pepper using rainfall and temperature as independent variables. The sensitivity analysis of the model was done by increasing and decreasing the values over a range of interest and yield was plotted as a function of change of the climatic parameters such as maximum and minimum temperature, carbon dioxide, day length and solar radiation. The calibration of the model was done using the already available data from the literature and the data generated from the field experiments. Validation of the crop model was done and the test results showed that the stimulated yields and observed yields were sufficiently close and that the model could be used for predicting the yield of black pepper.

S5 P2

Evaluation of enriched dairy waste compost as ingredient in potting medium for the production of rooted black pepper cuttings

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Dairy waste compost enriched with rock phosphate/poultry manure as one of the ingredients was evaluated for the production of rooted black pepper cuttings. Twelve treatments consisting of different potting mixtures were made by mixing the ingredients; soil, farmyard manure, sand, compost enriched with rock phosphate (CERP), compost enriched with poultry manure (CEPM) and coir dust in different proportions. Pooled analysis of the growth parameters of the cuttings of two harvests in serpentine method showed that plants raised in soil, CERP and coir dust in 2:1:1 proportion produced maximum shoot length (182 cm) and number of leaves (22) followed by those raised in soil, CERP and granite powder (2:1:0.5) proportion whereas less vine length (89 cm) and number of leaves (13) were observed in medium soil, FYM and sand in 2:1:1 proportion (control). Pooled analysis of growth parameters of harvested cuttings kept in shade indicated that plants raised in soil, CEPM and granite powder (2:1:0.5) had maximum height (49 cm), number of leaves (9), root length (23 cm) and biomass (3.8 g/plant) which was on par with the plants grown in soil, CERP and granite powder 2:1:0.5. Less production cost of cutting was noticed in the treatment soil, CERP and coir dust in 2:1:1 proportion (Rs. 8/rooted cutting) compared to control (Rs. 10/cutting). The results indicated that, soil, CERP, coir dust (2:1:1) can be used as an alternative medium to normal potting mixture for the production of rooted black pepper cuttings.

S5 P3

Evaluation of local black pepper (*Piper nigrum* L.) accessions under Assam condition

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Thirteen black pepper accessions *viz.*, KKHP 1, KKHP 2, KKHP 3, KKHP 4, KKHP 5, KKHP 6, KKHP 7, KKHP 8, KKHP 9, KKHP 10, KKHP 11, KKHP 12 and KKHP 13 collected from Kamrup district of Assam were evaluated for growth, yield and yield attributing traits, along with Panniyur 1 as check variety. The data on yield and yield attributing traits were recorded for seven years, from 2013 to 2019 and the mean data was used for analysis. Among the accessions, higher vine height (7.96 m) and vine column diameter (1.19 m) was recorded in KKHP 1 and KKHP 8, respectively. However, leaf length (14.64 cm), leaf breadth (10.20 cm), leaf area (104.63 cm²), leaf stalk length (2.14 cm), fresh weight (333.31 g) and dry weight (72.20 g) of 100 leaves was found to be significantly higher in the accession KKHP 13. Spike length among the accessions varied from 9.57 cm to 13.45 cm. Though the length of berry bearing portion was found to be higher in KKHP 8 (12.01 cm), the number of spikes per lateral branch (17.83), number of nodes per lateral branch (32.67), number of berries per spike (80.69), fresh yield per vine (6.02 kg) and dry yield per vine (2.14 kg) were found to be significantly higher in KKHP 13 as compared to other accessions. The accession, KKHP 13 showed high yield potential, with 21.86% higher fresh yield as well as 43.62% higher dry yield than the check variety Panniyur 1.

S5 P4

Evaluation of *Piper* (*Piper* spp.) rootstocks against slow wilt disease of black pepper (*Piper nigrum* L.)

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An experiment was conducted at Horticultural Research Station, TNAU, Yercaud during 2017- 2018 to identify root stocks tolerant to slow wilt disease. The rootstocks of *Piper* species such as *P. colubrinum*, *P. argyrophyllum*, IISR Thevam, IISR Shakthi, Panniyur 1 and Karimunda were inoculated with *Fusarium solani* and *Meloidogyne incognita* to evaluate against slow wilt disease. In order find out the resistance against *Fusarium* wilt, root stocks were inoculated with *Fusarium* culture and observations were recorded at 30 days after inoculation. The highest (87%) wilt percentage was observed in Panniyur 1 followed by *Piper argyrophyllum* (20%). Based on gall index parameter, the rootstocks were ranked in which, IISR Shakthi was found to be highly resistant (1), followed by *Piper colubrinum* (2), IISR Thevam (2) and Karimunda (2). The experiment revealed that *P. colubrinum*, IISR Thevam, IISR Shakthi and Karimunda as promising rootstocks against *Fusarium* wilt and root knot nematode.

S5 P5

Morpho-molecular characterization of *Athelia rolfsii* an upcoming pathogen challenging black pepper nurseries

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A collar rot disease affecting rooted cuttings of black pepper in the nurseries of Kerala was observed during August-October 2019. The rooted cuttings developed water-soaked appearance initially at the base. Further, rotting was noticed at the bark region just above the soil level which later advanced deeper into the stem. The decayed areas developed white mycelial growth advancing radially upwards. The mycelia got studded with mustard shaped sclerotial bodies in the later stages. The infected cuttings developed chlorosis of leaves followed by defoliation. Finally the mycelium of the pathogen completely covered the shoots, resulting in death of cuttings. The fungal culture in artificial medium appeared whitish to pinkish white with radially spreading white mycelial strands and developed light brown coloured sclerotial bodies measuring 0.6-1.7 mm in diameter. The pathogenicity was proved on two months old pepper cuttings by artificial inoculation with the mycelial discs. The mycelium of the pathogen was hyaline, septate, measuring 3-8 μm in width. The sclerotial bodies appeared after 11 days of incubation. Microscopic examination of sclerotia revealed brown pigmented rind of 11.7-26.6 μm width and hyaline inner cortex with barrel shaped cells measuring 7.2-15.6 \times 3.4-7.8 μm . PCR amplification and sequencing of the ITS rDNA region using universal primers of ITS (ITS 1F and ITS 4R) yielded an amplicon of 500 bp. The homology search of the sequence on NCBI database using BLASTn analysis showed 99-100 per cent homology with *Athelia rolfsii*. Owing to the soil-borne nature of the pathogen and capability to produce resistant survival structures, the disease is emerging as a serious threat challenging planting material production of black pepper in Kerala.

S5 P6

Performance of bush pepper under the forest canopy in combination with high value crops

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An experiment was undertaken at Horticultural Research Station, Pechiparai to study the comparative growth and yield performance of bush pepper under multitier cropping system of forest trees in combination with nutmeg and mangosteen and bush pepper in the lowest canopy during the period 2018-2020. The bush pepper plants were planted at different spacing *viz.*, 1 \times 1 m, 1.25 \times 1.25 m and 1.5 \times 1.5 m under nutmeg and mangosteen which were planted at a spacing of 8 \times 8 m, respectively. Within the square formed by four main crops, 30, 25 and 16 bush pepper plants were accommodated at a spacing of 1 \times 1 m, 1.25 \times 1.25 m and 1.5 \times 1.5 m, respectively. The results revealed that, the performance of bush pepper grown under forest trees and nutmeg at a spacing of 1 \times 1 m were superior

over the other treatments with a fresh yield of 23.26 kg per 100 m² area followed by growing bush pepper under forest trees and mangosteen at a spacing of 1 x 1 m with an yield of 21.75 kg per 100 m² area.

S5 P7

Ready to use neem oil-garlic soap: An effective IPM against black pepper stem mealybug

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An experiment was conducted at Pepper Research Station, Panniyur during 2018-19 to compare the effect of neem products for the management of stem mealybug infesting black pepper. An approved formulation of Kerala Agricultural University, ready-to-use (RTU) Neem oil-garlic soap (10 g/litre) was compared with two neem products *viz.*, IIHR Neem soap (6 g/litre) and a commercial formulation of neem, Nimbecidine EC (0.03%) @ 5 ml/litre and dimethoate (@ 0.5 ml/litre) as a check. RTU Neem oil-garlic soap (two sprays at one week interval) was most effective resulting in 90% mortality, which was on par with dimethoate. The mortality percentage of IIHR Neem soap was 60% and Nimbecidine was 50%. Due to the combined effect of neem oil, garlic and soap solution, as repellent and insecticidal actions, RTU neem oil garlic soap got an upper hand for the management of stem mealy bug. Another additional benefit was that, basal rot caused by *Sclerotium rolfsii* also could be controlled by this product.

S5 P8

Studies on floral traits and reproductive strategy in cultivated *Piper nigrum* L.- various degrees of dichogamy and herkogamy are discovered

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In *Piper nigrum*, the wild forms are dioecious while cultivated are either hermaphrodites or polygamodioecious. In the present study, 33 accessions of *P. nigrum* cultivars were selected and the flowering spikes were visualized under stereomicroscope to understand various floral traits like inter-floral distance, bract shapes and temporal (dichogamy) as well as spatial (herkogamy) arrangement of the anthers and stigma. Various degrees of sequential hermaphroditism were observed, with a firsthand report of protandry; suggesting evidence of tendency for cross pollination. A dendrogram was plotted with 19 reproductive characters for 33 cultivar accessions to understand the trend in sex expressional similarities between the cultivars. The findings suggested that, the adaptation ability or flexibility of *Piper nigrum* in coping up with different environmental conditions, even though there were relatively less success rate in the cross pollination already reported.

S5 P9

Studies on microbial contamination in stored black pepper

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A study was conducted to identify the microbial contaminants and estimation of piperine in black pepper. Twenty five market samples of black pepper from Idukki, Ernakulam and Alappuzha in Kerala were analyzed. The fungal contaminants encountered in the samples were *Aspergillus niger*, *A. fumigatus*, *A. flavus*, *Penicillium chrysogenum* and *Fusarium oxysporum*. The most predominant fungi encountered were *A. niger* and *A. flavus*. The piperine content in the samples were also estimated and found affected on prolonged storage suggesting adoption of proper storage methods so that the microbial contamination and consequent deterioration can be minimized.

S5 P10

Studies on pre and post infection management efficiency of fungicides against *Phytophthora capsici* in black pepper

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An *in vivo* trial was conducted to evaluate the efficiency of twelve different commercially available fungicides and a microbial consortium for the management of *Phytophthora capsici* in black pepper. All the fungicides tested provide more than 50% reduction over control when applied prophylactically. Among them, Acrobat MZ (Dimethomorph 9% + Mancozeb 60 WP), Aliette (Fosetyl Al), Bordeaux mixture, Ergon (Kresoxim methyl), Melody Duo (Iprovalicarb 5.5% + Propineb 61.25% WP), Sectin (Fenamidone 10% + Mancozeb 50% WG), Curzate (Cymoxanil 8% + Mancozeb 64% WP) and Kocide (Copper hydroxide) were found promising with more than 80% reduction over control. Whereas only seven fungicides *viz.*, Acrobat MZ, Aliette, Curzate, Sectin, Ergon, Melody Duo and Anthracol (Propineb 70WP) recorded 50% or more reduction in disease intensity when applied after the commencement of the disease. Among the different fungicides, Acrobat MZ and Aliette provided 100% protection to the plants when applied as prophylactic spray, while, 74.3 and 71.8% disease reduction, respectively when applied after the infection. Prophylactic spraying with Bordeaux mixture also provided 100% reduction in disease but the severity of the disease increased to 45.9% when it was applied after the initiation of the disease. Application of microbial consortium was found effective only when it was applied prophylactically.

S5 P11

Studies on the response of black pepper varieties for propagation by serpentine layering

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An experiment was conducted to study the response of black pepper varieties on production of planting material through serpentine layering during 2016 and 2017. Eight varieties of black pepper were evaluated and the results indicated that, Panniyur 7 recorded highest root length of 35.08 cm at 90 days after layering followed by Subhakara (33.5 cm at 90 days after layering). While the highest root mass was recorded in Panniyur 1 (10.12 at 90 days after layering) followed by Panniyur 2 (8.91 at 90 days after layering). Panniyur 1 also recorded the highest shoot length (31.78 cm at 90 days after layering) and the lowest was recorded in Panniyur 7 (21.50 cm at 90 days after layering). The maximum number of leaves, survival percentage and total number of planting material production were also highest in Panniyur 1. The highest number of planting material (in terms per vine) was produced by Panniyur 1 followed by Panniyur 2 and the crop growth rate was found to be highest in Panniyur 1 followed by Pournami.

S5 P12

Study on utility of different multipurpose trees as black pepper standards in lateritic soil of Uttara Kannada district

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The experiment was carried out in a farmer's field at Antravalli village (14.4711°N latitude, 74.4599°E longitude and 20 m above mean sea level) located in the Central Western Ghats near Kumta, Uttara Kannada district of Karnataka. The experimental results revealed that, at 90 DAI, significantly highest height was observed in black pepper trailed on *Aquilaria malaccensis* (1.46 m) followed by *Grevillea robusta* (1.37 m), *Swietenia mahagony* (1.28 m) and *Pajanelia longifolia* (1.25 m). The least height was recorded on vines trailed on *Gliricidia sepium* (1.08 m). However, percentage increase in height of the vines was maximum with *Grevillea robusta* (13.86%) followed by *Aquilaria malaccensis* (8.9%), *Pajanelia longifolia* (8.8%) and *Gliricidia sepium* (4.63%). The least per cent increase was observed with *Swietenia mahagony* (3.9%). The light transmission ratio (%) was maximum with *Grevillea robusta* (51.66%) followed by *Aquilaria malaccensis* (39.02%), *Pajanelia longifolia* (34.39%) and least for *Swietenia mahagony* (19.31%). In this study, the cardinal factor that decided suitability of MPTs as black pepper standards was growth. However, factors such as tree growth, physical suitability for trailing and commercial value of the tree were the important determinants of suitability as standards. Among the black pepper standards, *Grevillea robusta* seem to possess most of these traits to qualify as ideal support tree for black pepper.

S5 P13

Composition and characteristics of bulk soil microbial communities of cardamom plantations in Idukki, Kerala

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Soil microbes participate in almost every chemical transformation in the soil and also play a vital role in soil fertility as they are involved in C, N and P cycles which provide nutrients for plant growth. In the present investigation, bacterial, actinomycetes and fungal populations in 60 bulk soil samples collected from cardamom plantations in Idukki, Kerala were estimated. The bacterial population ranged from 2.2×10^5 to 6.8×10^5 , the actinomycetes from 1.0×10^5 to 1.8×10^5 and the fungi from 1.8×10^5 to 5.0×10^5 per gram of soil. Twenty eight bacterial and 22 fungal isolates were tested *in vitro* for their antagonistic activity against *Pythium*, *Phytophthora*, *Fusarium* and *Rhizoctonia* infecting cardamom. One among the bacterial isolates (B 14) and five fungal isolates (F 10, F 17, F 20, F 21 and F 22) exhibited more than 70% inhibition against two or three pathogens. The total bacterial population was low in soils with high organic carbon content and high with high available P, K, S and B. The bacterial population was low in soils with acidic pH (5 - 5.5) and highest in normal pH (> 5.5). The total fungal population was high in soils with low organic carbon, available P, K and B. The total fungal population was low in soils with low available S and normal pH and high in acidic pH.

S5 P14

Delineation of cumin production zone beyond boundaries based on climate analogues and soil suitability

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An investigation was carried out to identify ideal ecological niche that would produce similar yield as traditional centers in the future climate scenario by adopting an integrated approach of climate analogues and soil suitability. Climate analogue tool, a web-based tool developed by the Research Programme on climate change, agriculture and food security (CCAFS) which helps to identify, connect and map sites with statistically similar climates across space and time was employed in the preset study. The geographical coordinates of efficient zones under the crop in India based on relative spread index and relative yield index were used as the input/reference site for finding the analogue sites. Rainfall and temperature were the main climate variables used for the study under SRES A1B emission scenario. Similarity index with 0.75 to 1.0 were delineated as highly likely areas and 0.5 to 0.75 as moderately likely areas for cumin cultivation in future (2020 - 2049). The results showed analogue sites in 453 districts against 14 reference sites used for the study. The sites which were identified by the tool was further corroborated with the soil suitability

of the location. These sites showed varied soil types *viz.*, alluvial soil, black soil, red soil, mixed black and red soil, desert soil and hilly soil. All the sites except those with hilly soil were found suitable for cumin cultivation.

S5 P15

Evaluation of small cardamom (*Elettaria cardamomum* Maton.) hybrids for yield and rhizome rot resistance

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In the present study, progenies of 23 inter varietal F₁ hybrids of cardamom were evaluated for morphological and yield characters. From the pooled data of 3 years, nine superior hybrids were shortlisted and the capsule characters were recorded. Among the nine shortlisted hybrid progenies, progeny number 14 of ICRI 4 × IISR Vijetha recorded highest fresh (1090 g) as well as dry yield (236 g) of capsules per plant. Capsules of ICRI 4 × IISR Vijetha (14) were globose, bold (11.06 mm) and pale green in colour. Among the shortlisted hybrid progenies, PV 2 × IISR Vijetha (1), Mudigere 3 × IISR Vijetha (5), ICRI 4 × IISR Avinash (2), ICRI 4 × IISR Vijetha (14), Mudigere 1 × IISR Vijetha (1) and Mudigere 1 × IISR Vijetha (2) were evaluated against rhizome rot by challenge inoculation under pot conditions. The results revealed that, none of the hybrid progenies exhibited rhizome rot symptoms even after copious flooding and were subsequently shortlisted as resistant to rhizome rot.

S5 P16

First report of *Marasmiellus* sp. on small cardamom *Elettaria cardamomum* (Maton) and its *in vitro* management

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The present investigation focused on the incidence of a new disease on cardamom in various locations of cardamom hill reserves in Idukki district of Kerala (Erattayar, Pampadumpara and Konnathadi panchayaths) during wet humid season. The symptoms of the disease developed as brown discolouration on the outer sheath. Within the sheath, signs of the pathogen developed as white mycelial growth which slowly progressed to inner sheaths leading to drying and death of the plant. On isolation, fluffy white colonies of the pathogen was developed on artificial media which later turned cream colour. Microscopic studies revealed that the pathogen was non-sporulating with branched hyaline hyphae. The identity of the pathogen was confirmed by partial sequencing of ITS region. The pathogen showed 99.57% similarity with *Marasmiellus* sp. based on BLAST analysis. Among the 11 fungicides evaluated under *in vitro*, cent per cent inhibition was shown by Mancozeb 75 WP and Copper oxychloride 50 WP as well as systemic fungicides such as Propiconazole 25 EC and Hexaconazole 5 SC and combination products *viz.*, Propiconazole 13.9 +

Difenaconazole 13.9 WP and Captan 70 + Hexaconazole 5 SC. Least inhibition (39.26%) was observed with potassium phosphonate. Among the bioagents evaluated, *Trichoderma viride* showed more than 55% inhibition in mycelial growth whereas, *Pseudomonas fluorescens* showed no inhibition in the growth of the pathogen.

S5 P17

Management of pseudostem rot disease of small cardamom through fungicides and bioagents

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In the present investigation, both chemical and biological strategies were assessed to manage pseudostem rot of cardamom at field level during 2017-18, 2018-19 and 2019-20. The pooled analysis of data revealed that, spraying carbendazim @ 0.2% showed minimum per cent tiller infection (5.38%) which was on par with biocontrol treatment; soil application of *Trichoderma harzianum* (50 g/vine) + neem cake (1 kg/vine) + spray of *Pseudomonas fluorescens* (2%). The treatment, carbendazim @ 0.2% gave maximum yield of capsules (805.5 g/plant) which was on par with *Trichoderma harzianum* (50 g/vine) + neem cake (1 kg/vine) + spray of *Pseudomonas fluorescens* (2%) (762.75 g/plant). The untreated control showed 13.48 per cent of tiller infection with yield of 427.94 g/plant. The experiment revealed that, pseudostem rot of small cardamom can be managed by spraying carbendazim (0.2%) or soil application of *Trichoderma harzianum* (50 g/vine) + neem cake (1 kg/vine) along with foliar spray of *Pseudomonas fluorescens* (2%).

S5 P18

Phoma sp., A new threat to small cardamom [*Elettaria cardamomum* Maton]

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Recently a new fungal disease was observed in various parts of cardamom hill reserves of Idukki district in Kerala. The symptoms on leaves initiated as reddish brown round to oval spots. When enlarged the centre of the spot becomes creamish white surrounded by reddish brown margin. Later these spots were coalesced to give a blighted appearance. In the advanced stages, the centre portion turned papery and shred. Similar symptoms were also observed on leaf axils and tillers. On tillers, the lesions spread to several centimeters in length at times. The affected portion had straw coloured centre with reddish brown margin. On advanced condition, the infection proceeds to the inner sheaths which split open longitudinally leading to collapse of the plant. On isolation, white to mouse black, floccose colonies with fuscus black colour on the reverse side was developed 2-3 days after incubation. The hyphae were olivaceous to dark brown with constriction near septa, branched, septate and upto 8.5 µm thick. The fruiting bodies or conidiomata were globose to subglobose, oval and brown. Thick walled brown chlamydospores were formed in

chains. The conidia were cylindrical, hyaline, smooth walled, aseptate, $3.72\text{-}5.77 \times 1.5\text{-}2.5$ μm in dimension. Based on the morphological, microscopical and molecular studies, the pathogen was identified as *Phoma* sp. (NCBI MN962956). Under *in vitro* condition, systemic fungicides like Propiconazole 25 EC, Hexaconazole 5 SC as well as combination fungicides like Captan 70 + Hexaconazole 5 WP and propiconazole 13.9 + Difenaconazole 13.9 WP were found effective against the pathogen.

S5 P19

Plant morphological traits associated with field resistance to cardamom thrips *Sciothrips cardamomi* in cardamom *Elettaria cardamomum*

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The present study aimed at identifying sources of resistance against cardamom thrips and the associated plant morphological traits conferring resistance against the pest. Field screening of 180 cardamom germplasm accessions for three years at ICAR-IISR Regional Station, Appangala, Karnataka resulted in identification of eight accessions resistant to cardamom thrips. Differences in panicle type and the nature of adherence of leaf sheath to the pseudostem explained a significant amount of the variance in resistance and therefore are likely to play a major role in conferring resistance against this pest. Multiple regression analysis of the different traits indicated that accessions with prostrate panicles having leaf sheath loosely adhered to the pseudostems were found to have significantly less thrips damage when compared to other panicle and leaf sheath types. However, persistence of flower bract did not have a significant additive effect on imparting resistance against thrips. Metabolomic analysis of the accessions may provide further insight into the existence of supplementary biochemical mechanisms, if any, in imparting resistance. The identified traits and accessions can be exploited in future breeding programmes for developing thrips resistant cardamom varieties.

S5 P20

Studies on microbial contamination in stored small cardamom

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In the present study, microbial contamination in 25 cardamom samples collected from various markets in Idukki, Kerala was analyzed. The samples were examined for fungal and bacterial profile and a total of 8 fungal isolates representing 5 genera were isolated and identified. The fungal isolates obtained from cardamom samples were *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *A. ochraceus*, *Fusarium oxysporum*, *Penicillium chrysogenum*, *P. brasilianum*, *Trichoderma* sp. and *Rhizopus* sp. The most predominant fungal species encountered were *A. flavus* and *Penicillium* spp. The oil profiling of healthy and affected samples and biochemical analysis of dominant microflora were carried out which showed poor quality of the samples.

S5 P21

Studies on leaf blight disease of large cardamom caused by *Colletotrichum gloeosporioides*

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In the present investigation, five cultivars of large cardamom including ICRI Sikkim 1 and ICRI Sikkim 2 were evaluated against blight disease during 2014 to 2018 under natural field conditions. The results indicated that, the varieties such as Sawney, Seremna and ICRI Sikkim 1 had minimum disease incidence. Further, a trial was conducted to evaluate the effect of *Pseudomonas fluorescens* and butter milk to manage the disease during 2014 to 2018 and the results showed that, *Pseudomonas fluorescens* (5%) was superior over other treatments. Sixty one Cardamom Blight Escapes (CBE) accessions were collected from various locations of Sikkim and Darjeeling, West Bengal which included Varlangey (19), followed by Dzongu Golsey (15) and Ramsey (14). Only one accession was recorded for the cultivar Ramla as disease escape.

S5 P22

Association of two novel viruses with chlorotic fleck disease of gingerA I Bhat*, K P Naveen, N S Pamitha & R P Pant¹

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Chlorotic fleck disease of ginger, the causal virus of which was unknown so far is an important production constraint of ginger in India and other parts of the world. In the present study, two new RNA viruses were discovered in chlorotic fleck affected plants by the virome analysis using high throughput sequencing of small RNA (sRNA) and transcriptome. The high throughput sequencing results were verified through reverse transcription polymerase chain reaction (RT-PCR) using total RNA from infected plant and primers designed to the contigs that hit both viruses. The cloning, sequencing and phylogenetic analysis of complete genome of one of the viruses considered to be a new member of the family Tombusviridae while partial genome analysis of the other virus considered being a new member of the genus *Ampelovirus* (Family: Closteroviridae). Therefore the tentative names corresponding to these viruses are ginger chlorotic fleck associated tombusviridae virus (GCFaTV) and ginger chlorotic fleck associated ampelovirus (GCFaAV). A reliable RT-PCR and SYBR Green-based real-time RT-PCR assays were developed for the detection of both viruses in plants that would aid in the identification and propagation of virus-free ginger plants. The viral population analysis in the field infected plants showed that both viruses more or less occur in equal concentration.

S5 P23

Comparative analysis of host-virus interaction deduced through symptomatology, physiological alterations and detection of viruses in ginger (*Zingiber officinale* Rosc.)

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In the present study, attempts were made to analyze the host-virus (es) interaction through symptomatological variations in germplasm accessions, physiological alterations and also detection of virus (es) infecting ginger through molecular diagnostic tool. The observations were recorded consecutively during 2016-2019 in 520 ginger accessions collected from diverse agro-climatic regions. The germplasm accessions were categorized as apparently healthy, mild, moderate and severe based on foliar symptoms manifested as light green/yellow streaks formed intravenously. Among the accessions which consistently expressed characteristic unique symptoms for three years, 80 were grouped under apparently healthy while, 82, 55 and 40 accessions were categorized as mild, moderate and severe, respectively. The asymptomatic apparently healthy accessions were subsequently subjected to real-time polymerase chain reaction to confirm the virus-free status of which, 42 accessions were found free from viruses. Analysis of various physiological parameters in apparently healthy and severe categories of ginger varieties *viz.*, IISR Mahima, IISR Varada and IISR Rejatha revealed that, peroxidase, polyphenol oxidase, catalase and ascorbate peroxidase enzymes activity, total protein and internal CO₂ concentration were low in apparently healthy and high in severe category. In contrast, acid phosphatase activity, chlorophyll (a and b), transpiration rate, stomatal conductance and photosynthetic rate were low in severe and high in apparently healthy category. The information generated from the present study would help in utilizing the accessions identified as virus-free for further development as varieties considering their beneficial agronomic traits, quality profile as well as resistance to biotic stresses and also employing the physiological parameters as indicators of resistance or susceptibility while screening the genotypes.

S5 P24

Development of native bacterial antagonist for the management of *Pythium* rhizome rot in ginger (*Zingiber officinale*)

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It is a well-known fact that native strains of biocontrol agents are more effective and have potential to control the plant disease than the introduced strains of biocontrol agents. Hence, the present study to manage rhizome rot in ginger is proposed with the following aim and objectives. To Isolate and characterize bacterial strains from the rhizosphere soil of ginger from different ginger growing tracts of Kerala, to screen *in vitro* and *in vivo* bacterial isolates and potential native bacterial antagonist against *Pythium*, to identify promising bacterial antagonist against rhizome rot in ginger through field evaluation, to study the mechanism of action and development of a protocol based on the potential antagonistic isolates and to develop a bio intensive management protocol for rhizome rot in ginger using native bacterial antagonist. The paper will discuss the results of the study in detail.

S5 P25

Effect of insecticides against shoot borer, *Conogethes punctiferalis* in ginger

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In the present study, field experiments were conducted at Krishi Vigyan Kendra, Thirupathisaram with eight treatments including untreated check with the variety Vardha. The results indicated that, the mean per cent damage was less with Flubendiamide @ 75 ml/ha (3.15%) application compared to 27.75 per cent in the untreated check which also resulted in higher per cent reduction of dead heart symptom (88.75%). Considering the cost of rhizome yield, cost of plant protection, profit per hectare, the cost benefit ratio was found higher with Flubendiamide @ 75 ml/ha (2.27).

S5 P26

Evaluation of organic amendments for the management of shoot borer, *Conogethes punctiferalis* and rhizome rot in ginger

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In the present study, field experiments were conducted to manage shoot borer and rhizome rot in ginger. The results revealed that, the treatment combination like farmyard manure (FYM) (12.5 t/ha) + azophos (2 kg/ha) + soil application (each 2.5 kg/ha) with *Trichoderma viride* and *Pseudomonas* + soil application with neem cake @ 1000 kg/ha with application of neem-based formulation (Azadirachtin) 10000 ppm @ 1000 ml/ha and copper oxychloride (0.3%) for the suppression of major pest and disease viz., shoot borer and rhizome rot in ginger by recording 87.5% and 83.25%, respectively, which also resulted in higher rhizome yield and better cost benefit ratio.

S5 P27

Impact of good agriculture practices on eco-friendly and sustainable production of ginger

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To address the issues of lower productivity and environmental pollution, a project was implemented with financial assistance from Government of Karnataka during 2015-2019 with special reference to small and marginal farmers growing ginger. Under the project, front line demonstrations on use of ginger special (548 No.), training programmes (24 No.), field days (2 No.), method demonstrations (8 No.), diagnostic field visits (25 No.) and radio/TV programmes (04 No.) were conducted by involving 1810 farmers/extension workers in four taluks of Shivamogga district. The beneficiary farmers adopted the good agriculture practices viz., rhizome treatment, use of bio-inoculants enriched FYM, growing pigeon pea as a border row, judicious use of nutrients, eco-friendly plant protection measures, use

of high yielding varieties, following maturity indices for harvesting, proper storage and recorded Rs. 0.7 lakh/ha as additional income compared to non-beneficiary farmers. Due to the intervention there was a substantial impact on adoption of GAP, productivity and income of the ginger farmers.

S5 P28

Influence of priming in ginger (*Zingiber officinale* Rosc.) transplants

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The present study was undertaken to assess the performance of primed protray transplants in nursery with 13 treatments in four periods of storage, from zero month to three months. The study revealed that, the priming influenced survival rate, days to sprouting, plant height, number of leaves etc. The mean survival rate was superior (58.89%) when planted after three months after storage irrespective of the priming treatments. The least survival rate of 11.6% was recorded when planted immediately after harvest. However, the survival rate was found to increase drastically to 50.3% and 50.1% in one month and two months after storage, respectively. In pooled analysis, among various priming treatments, Ethepon 200 ppm performed better (68.66%) irrespective of storage period. Priming with Ethepon 200 ppm was superior with survival rate of 96.9% and 99% when planted one and two months after storage, respectively. Hence, ginger transplants can be raised with seed rhizome stored even for one month, if primed with Ethepon, 200 ppm, for the off-season production of green ginger under Kerala condition.

S5 P29

Organic cultivation of ginger as an intercrop under coconut plantation-Available option to the farmers of Andaman and Nicobar islands

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In the present study, a field demonstration was conducted at Horticulture Research Farm, ICAR- Central Island Agricultural Research Institute, Sipighat for organic cultivation of ginger var. Jorhat under 40 years old coconut plantation and in open condition. The crop management practices included basal application of organic manure *viz.*, farm yard manure, seed treatment before sowing with biocontrol agent *viz.*, *Trichoderma viride*, Glyricidia green leaf mulching after sowing and after 45 days, 90th day after planting, weeding and earthing up after 45 days of planting and again at 90 days after planting and application of neem cake. The crop was harvested at 8-9 months after planting during December-January. The yield ranged from 6-8 t/ha under open condition while under intercropped condition in coconut plantation, the average yield ranged from 10-11 t/ha. Considering the prevailing market rate of Rs. 100-150 per kg of ginger, there is a potential to fetch about Rs. 10 lakhs as additional gross income for the farmers by adopting ginger as an intercrop in their existing coconut plantations under Andaman conditions.

S5 P30

Performance evaluation of high yielding ginger (*Zingiber officinale* Rosc.) varieties under organic nutrition for sustainable farming

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A trial was conducted with ginger varieties Athira, Karthika, Aswathy, Varada and a local variety to evaluate the performance under organic system. The results revealed that, ginger variety Varada recorded highest yield (18.5 t/ha) followed by Aswathy (16.7 t/ha), while the local variety recorded lowest yield (10 t/ha). Highest B:C ratio (2.63) was obtained from Varada followed by Aswathy (2.38) and Athira (2.32). Highest disease incidence (25%) was recorded in the local variety followed by Karthika (8%) and lowest in Varada (5.2%). The pest incidence (15.4) was highest in local variety and lowest (4.3%) in Varada. The rhizomes of ginger variety Varada and Athira were bold, while that of Aswathy and Karthika were medium bold. The varieties Varada, Athira and Karthika can be used for fresh and dry ginger purpose while variety Aswathy can be used for fresh ginger purpose. It is concluded that, ginger performs well under organic farming and Varada with highest yield and benefit cost ratio and less pest and disease incidence performed better in Kollam district of Kerala under organic management practices.

S5 P31

Rhizosphere priming effect on nutrient mineralization dynamics of crop residues in gingerV Srinivasan*, R Dinesh, P Mohammed Thanveer¹, Alok Tiwari¹ & S Hamza

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An incubation study was conducted with three crop residues (Glyricidia, Ailanthus and mixed leaves) added with and without rhizosphere priming (with FYM and ginger crop) to study mineralization of major nutrients, more specifically N for a period of six months and the effects on mineralization pattern, nutrients addition and microbial growth were recorded at regular intervals. The rate of NO₃-N mineralization was found to be significantly higher in the treatments with ginger over treatments without ginger, indicating the positives of rhizosphere priming effect. Highest NO₃-N and NH₄-N release was found with Glyricidia. The application of FYM and presence of ginger decreased the cumulative and net release and mineralization rate of NH₄-N and the total N mineralization rate. The rate of total N mineralization was higher when crop residues were treated without FYM or ginger. The priming effect influenced the microbial activity and resultant effect was seen in the microbial biomass C, N and P and also in the enzyme activity. Almost 10 times higher net P release was observed between with FYM and without FYM treatment. Among mulches, net P release was higher in Ailanthus. Higher soil pH, OC buildup and soil enzyme activities were observed in FYM addition and ginger rhizosphere. The FYM priming increased the dry matter production of ginger by 48% and by 88%, 100% and 75% the N, P and K uptake,

respectively as compared to without FYM. Even though cumulative N and K release was higher in *Glyricidia* followed by mixed leaves, the total nutrient uptake by the plant was higher in *Ailanthus*, which might be due to the prolonged release of N, P and K from *Ailanthus* and extended supply of these essential nutrients till 90-160 DAT for ginger during its critical growth period.

S5 P32

Yield and nutrient uptake of ginger (*Zingiber officinale* Rosc.) as influenced by organic manures and Bio-stimulants

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A trial was undertaken to study the effect of organic manures (FYM, neem cake, vermicompost, *Azospirillum*) and biostimulants (Panchakavya, humic acid and PPFM) on yield and nutrient uptake of ginger. The maximum green rhizome yield (23.55 t/ha) was obtained with the application of 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + Panchakavya (3%) per hectare and minimum with the control (12.16 t/ha). Uptake of nitrogen was highest with the application of 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + Panchakavya (3%) per hectare (119.06 kg/ha) followed by application of 11.25 tonnes of FYM + 1.25 tonnes of vermicompost + Panchakavya (3%). The maximum amount of phosphorus uptake (14.35 kg/ha) was recorded with the application of 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + humic acid (0.1%). Uptake of potassium was highest with the application of 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + Panchakavya (3%) per hectare (197.56 kg/ha) followed by application 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + humic acid (0.1%) (175.55 kg/ha). The data revealed that, the application of 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + Panchakavya (3%) per hectare favourably influenced yield and uptake of nutrients by ginger followed by the application 7.5 tonnes of FYM + 375 kg of neem cake + 1.25 tonnes of vermicompost + 5 kg of *Azospirillum* + humic acid (0.1%) (175.55 kg/ha).

S5 P33

Distinctiveness, uniformity and stability (DUS) characters of turmeric (*Curcuma longa* L.) germplasm

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The present investigation was carried out at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India during 2017-2019. The experiment was laid out at an augmented

block design consisting of 20 blocks with two checks *viz.*, BSR 2 and CO 2. In the present investigation, 200 germplasms from different sources of the country were taken into consideration for genetic variability analysis and evaluation of different characters as specified by the Distinctiveness, Uniformity and Stability characters evaluated by ICAR-Indian Institute of Spices Research, Kozhikode. The characterization was done in 200 germplasms and grouped according to the DUS characterization such as plant, leaf, flowering and rhizome characters. All the germplasms were also compared with TNAU released varieties.

S5 P34

Effect of chemical weed management on growth, yield and economics of transplanted turmeric

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The experiment was conducted at KRCCH, Arabhavi during 2017-18 to study the effect of different weed management methods on growth, yield and quality of transplanted turmeric (Cv. Salem). The results revealed that, polythene mulching recorded highest values for growth attributes like average plant height (52.4 cm), plant spread (32.27 cm), number of tillers per plant (2.2), number of leaves (8.4) and its area (233.67 cm²) at 180 DAT and resulted in highest yield (11.67 t ha⁻¹), net returns (Rs. 121019) and benefit:cost ratio (2.1). While, the same parameters were lowest in unweeded control (38.53 cm, 26.03 cm, 1.13, 6.33, 110.7 cm², 2.10 t ha⁻¹, Rs. 57963 and 0.42, respectively). Among the herbicides, application of Oxyflourfen 23.5% EC @ 0.3 kg a.i. ha⁻¹ recorded higher values (50.93 cm, 31.90 cm, 1.80, 8.13, 222.86 cm², 7.44 t ha⁻¹, RS. 45489 and 1.43, respectively). Whereas, Metribuzin 70% WP @ 1.05 kg a.i. ha⁻¹ recorded lower values for these parameters (41.07 cm, 26.23 cm, 1.27, 6.4, 116.82 cm², 2.36 t ha⁻¹, Rs. 55987 and 0.46, respectively) and found to be toxic to the transplanted turmeric.

S5 P35

Evaluation of promising turmeric genotypes for Andhra Pradesh

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A trial was undertaken to evaluate promising genotypes from various coordinating centers under All India Research Project on Spices at Horticultural Research Station, Lam from 2016 to 2019. The three year analysis of pooled data indicated that, the genotypes differed significantly for yield attributes and yield. Among the genotypes, LTS 1 and LTS 4 recorded significantly more plant height (110.7 cm and 111.1 cm, respectively), number of leaves per plant (19.3 and 17.5, respectively), leaf length (49.2 cm and 47.9 cm, respectively),

leaf width (15.5 cm and 15 cm, respectively), weight of primary rhizomes (248.5 g plant⁻¹ and 244.3 g plant⁻¹, respectively) and clump weight (426.4 g plant⁻¹ and 437.7 g plant⁻¹, respectively) over the check Mydukur (93.8 cm, 14.9, 41.6 cm, 13.7 cm, 214.7 g plant⁻¹ and 377.3 g plant⁻¹, respectively). However, considering the yield performance (fresh yield), the entries LTS 1 (37.3 t ha⁻¹), LTS 2 (37.9 t ha⁻¹), LTS 3 (37.4 t ha⁻¹) and LTS 4 (38.3 t ha⁻¹) were found significantly superior to the check Mydukur (32.7 t ha⁻¹). The curcumin content (% dry weight basis) was highest in RH 80 (4) and lowest in PTS 2 (3.1), whereas the check Mydukur contained 3.3%. The dry recovery was highest in LTS 3 (24.2%), whereas the lowest dry recovery was observed in IT 23 (16.3%).

S5 P36

Evaluation of turmeric for tolerance to foliar diseases

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An experiment was carried out to evaluate turmeric germplasm for resistance to foliar diseases *viz.*, leaf spot (*Colletotrichum capsici*) and leaf blotch (*Taphrina maculans*). Twelve turmeric lines from different parts of India [CL 32, CL 34, CL 52, CL 54 (from Coimbatore), RH 406, RH 407, RH 410 (from Dholi), TCP 14, TCP 129, TCP 161 (from Pundibari) and TCP 2 (local check from Pundibari) and Pratibha (National check)] were included in the trial. The experiment started during 2013-14 and completed during 2018-19. TCP 129 recorded lowest leaf blotch (PDI 8.23) disease severity among the 11 germplasm tested. TCP 14 recorded the lowest leaf spot disease severity (PDI 5.52) followed by TCP 129 (PDI 8.23). TCP 129 had 72.24% and 53.53% less leaf blotch and leaf spot disease, respectively over the local check. Overall, 10 germplasm recorded lower leaf blotch disease severity and 5 germplasm recorded lower leaf spot disease severity compared to the local check (TCP 2). The highest yield of 13.3 kg/plot (26.81 t/ha) was realized in TCP 129 followed by TCP 14 with 11.4 kg/plot (22.98/ha).

S5 P37

Increasing productivity of turmeric (*Curcuma longa*) through organic nutrient management and variety in north east India with special reference to Arunachal Pradesh

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A field experiment was conducted with an objective to increase the productivity of turmeric through organic management and variety during 2017-18 to 2019-20. The results of three year experimentation as well as pooled mean indicated significantly taller plant, higher fresh weight of clump and yield per hectare (31.48, 34.47, 36.35 and 34 t/ha) with the treatment of organic package developed by ICAR-IISR (GRB 35 capsule, FYM @ 20 t/ha, neem cake @ 2 t/ha, vermicompost @ 2 t/ha, ash @ 0.5 t/ha and IISR turmeric booster micronutrient @ 5

g/litre) as compared to recommended package of SAU (FYM @ 25 t/ha and vermicompost @ 5 t/ha). Other characters such as number of tillers/plant, days to attain 80% maturity and dry recovery under study could not be significantly influenced by the treatments. Among the three varieties, the variety NDH 98 recorded significantly taller plant, higher fresh weight of clump, yield per hectare (39.52, 42.17, 38.15 and 39.88 t/ha) and maximum number of days to attain 80% maturity during the three years of investigation and also the pooled mean. However, the dry recovery and number of tillers were higher in the variety Pratibha as compared to variety NDH 98 and Megha Turmeric 1 but remained at par with the variety NDH 98 in case of numbers of tillers. The interaction of treatment and variety was found to be not significant.

S5 P38

Management of leaf blotch disease of turmeric

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An experiment was conducted to assess field efficacy of four fungicides *viz.*, Propiconazole 25% EC (0.1%), Bordeaux mixture (1%), Copper oxychloride 50% WP (0.25%) and Zineb 75% WP (0.25%) and two biocontrol agents *viz.*, IISR *Trichoderma* liquid formulation (1%) and IISR *Pseudomonas* talc formulation (1%) through rhizome treatment + foliar spray at 90, 105 and 120 days after planting (DAP) against leaf blotch of turmeric. Application of Zineb 75% WP (0.25%) resulted in least per cent disease intensity (13.34 PDI) and maximum disease reduction over control (71.74%). Propiconazole 25% EC (0.1%) was the most effective in achieving maximum yield (38.09 t/ha) consequently resulting in maximum yield increase over control (47.8%). Best incremental cost benefit ratio of 1:22.22 was recorded with Zineb 75% WP (0.25%).

S5 P39

Management of root-knot nematode, *Meloidogyne incognita* infecting turmeric (*Curcuma longa* L.) under coconut cropping system

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A field experiment was conducted to manage root knot nematode, *Meloidogyne incognita* infecting turmeric (var: IISR Pratibha) with *Trichoderma harzianum* (ICAR-IISR and ICAR-CPCRI isolates) and *Pochonia chlamydosporia* (ICAR-IISR isolate) based talc formulations, neem cake, marigold and carbosulfan 25 EC (standard check) under coconut cropping system during 2016 and 2017 at ICAR-CPCRI Experimental Farm, Kasaragod. The talc formulation was applied @ 50 g/bed (mixed with 2 kg FYM), neem cake @ 1 kg/bed at the time of planting pre-monsoon (June) and post-monsoon (October) and marigold @ 30 plants/bed were compared with untreated and standard check i.e., carbosulfan 25 EC

(0.1%) @ 5 l/bed at the time of planting pre-monsoon (June) and post-monsoon (October) against root knot nematode. The results demonstrated sustained suppression of *M. incognita* population in soil as well as reduction in gall index (0.5 and 1) in turmeric plants treated with talc formulations of fungal bioagents compared with control (gall index 5). The persistence of *T. harzianum* and *P. chlamydosporia* in soil was confirmed by recording CFU at bimonthly intervals through random sampling. The talc formulations of fungal bioagents were found promising against *M. incognita* and resulted in improvement in health of turmeric plants as well as increase in rhizome yield.

S5 P40

Performance of turmeric cultivars for growth and yield attributes under rainfed Jammu subtropics

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Fourteen turmeric cultivars were evaluated for growth and yield attributes during 2015-16 and 2016-17 under rainfed conditions. Maximum plant height (112.2 cm) was recorded in Rajendra Sonia which was at par with Suguna (107.3 cm). Average number of fingers per rhizome ranged between 10.1-15.4 with maximum in IISR Prabha and minimum in IISR Kedaram. However, SJT 01, PH 1, Rajendra Sonia, Suguna and Alleppey Supreme were at par with IISR Prabha. Various cultivars showed non-significant effects towards average length and girth of fingers. The length of fingers ranged between 3.8-6.2 cm. Whereas, girth of fingers was recorded between 2-2.8 cm. IISR Prabha took minimum days to mature (197), while Megha took maximum number of days to mature (305). The average yield ranged between 16.4-28.4 t/ha with IISR Prabha, recording a yield of 28.4 t/ha followed by PH 1 (27.2 t/ha), Alleppey Supreme (26.5 t/ha), Rajendra Sonia (25.5 t/ha) and Suguna (25 t/ha). Sugandham had minimum yield potential of 16.4 t/ha which was at par with Suroma and Suvarna.

S5 P41

Physiological changes in turmeric genotypes subjected to water stress

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In the present study, morphology, stomatal density, relative water content (RWC), membrane permeability and epicuticular wax content in 50 elite turmeric genotypes were analyzed to identify drought tolerant types and to enunciate the mechanism of drought tolerance. Severe water stress significantly decreased the leaf relative water content and increased membrane permeability. The epicuticular wax content varied significantly among genotypes. Decrease in the number of stomata was a morphological change observed in response to drought stress. Few genotypes were found to be more tolerant with higher RWC, lesser membrane permeability, higher wax content and fewer stomata than other genotypes. RWC ranged from 85.77(Ranga) to 93% (Amballur and BSR II) under control,

while it ranged from 60.6 (Acc. 849) to 76.5% (Roma) after 10 days of water stress. Highest wax content (15.96 $\mu\text{g}/\text{cm}^2$) was recorded in SL 4 and lowest (6.24 $\mu\text{g}/\text{cm}^2$) in NTC 189.

S5 P42

Response of turmeric transplants (*Curcuma longa* L.) to fertigation system

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An experiment was carried out during 2014-2016 to study the effect of fertigation with N and K on yield and quality parameters of turmeric transplants. Yield data of two seasons showed that, there was a significant difference between farmer's practice and fertigation treatments and it was observed that the treatment in which fertigation with N and K @ 125% RDF through water soluble fertilizers, once in a week recorded maximum fresh rhizome yield per plant (406.27 g), estimated fresh rhizome yield per hectare (43.9 t ha⁻¹), estimated cured rhizome yield per ha (7.96 t ha⁻¹) and curing percentage (18.12%). Assessment of economics of cultivation with respect to different fertigation treatments clearly indicated the superiority of fertigation treatments over the conventional treatment, as both net returns as well as the BCR were higher in the fertigation treatments. The highest net returns and benefit-cost ratio were recorded in fertigation with N + K @ 100% through water soluble fertilizers once in a week and recorded the benefit-cost ratio of 3.65 as compared to other fertigation treatments. Even though the production cost was higher, water soluble fertilizers performed better with respect to yield and benefit-cost ratio. It is concluded that, fertigation with N + K @ 100% through water soluble fertilizers applied at weekly intervals enhance productivity and result in higher returns in turmeric transplants.

S5 P43

Response of turmeric varieties to organic farming under humid tropics of Kerala

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An experiment was conducted during 2014-2019 to evaluate the effect of organic management system on yield and quality parameters of turmeric using 11 different varieties. All the 11 turmeric varieties viz., Pratibha, Alleppey Supreme, Varna, Sobha, Sona, Kanthi, Suvarna, Suguna, Sudarsana, Kedaram and Prabha were imposed with single organic practice (30 t FYM + 2 t neem cake + 1 t ash + 4 t vermicompost per ha, biofertilizer; *Azospirillum* and *Pseudomonas* sp. as seed treatment and spray with neem oil for pest control). Among the varieties, significantly higher yield was recorded in Suguna (38.47 t/ha) followed by Sudarsana (36.52 t/ha). Among the varieties, significantly higher oil content was noticed in Pratibha (5.72%) followed by Alleppey Supreme (5.47%). Maximum oleoresin content was noticed in Prabha (15.06%) followed by Kedaram (14.75%). The variety Suguna recorded maximum curcumin (6.14%) which was on par with Alleppey Supreme (6.13%) and Kedaram (6.09%). Considering yield and curcumin content the best responsive variety to organic cultivation practice was found to be Suguna.

S5 P44

Root lesion nematodes (*Pratylenchus* spp.) emerge as a serious soil-borne pest across turmeric growing states of India

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Surveys were undertaken in major turmeric growing states during 2019-2020 and composite soil (123 nos.) and rhizome (95 nos.) samples were collected from turmeric fields of Andhra Pradesh, Telangana, Kerala and Tamil Nadu. Burrowing nematode (*Radopholus similis*), root knot (*Meloidogyne* spp.), lesion (*Pratylenchus* spp.), reniform (*Rotylenchulus reniformis*), lance (*Hoplolaimus* spp.), spiral (*Helicotylenchus* spp.), needle (*Longidorus* spp.) and stunt (*Tylenchorhynchus* spp.) were found associated with the samples. The examination of samples revealed that the range of absolute frequency was 44.3 to 86.5 and relative frequency, 10.1 to 19.7. Among the plant parasitic nematodes, the absolute frequency of *Pratylenchus* spp. was 63.7 and relative frequency, 14.5. The highest population levels were recorded in Tumuluru location (5.5 nematodes/g of soil) of Guntur, Andhra Pradesh, Thaneer panthal region (3.2 nematodes/g soil) of Coimbatore and Gobichettipalayam region (4.7 nematodes/g soil) of Erode in Tamil Nadu. The nematodes induced symptoms like stunted growth, yellowing of leaves, scorched leaf margins, early maturity than healthy plants and wilting during day time in turmeric. The infected rhizomes appeared light grey in colour, dried and wrinkled with dark brown spots, 3-5 mm deep from the outer surface. Association of *Pythium* spp. and *Fusarium* spp. was also recorded. Infected rhizomes stored in cold storage (4-8°C) resulted in 100% mortality of nematodes after 35 days of storage. Preliminary screening of different biocontrol agents like actinomycetes, plant growth promoting rhizobacteria and endophytic bacteria for their nematocidal potential showed that the lesion nematodes treated with *Pseudomonas putida* BP25 resulted in 92.7% mortality followed by endophytic isolates PEB3 (79.95%) and Act 2 *Kitasatospora setae* KM 6054 (76.7%) under *in vitro* conditions.

S5 P45

Yield loss assessment by linear regression model and effect of plant growth promoting rhizobacteria (PGPR) growth, yield and foliage disease suppression in turmeric (*Curcuma longa* L.)

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A trial was conducted during 2018-19 with five treatments *viz.*, POP + *Trichoderma* (talc formulation) + GRB 35 (talc formulation), POP + *Trichoderma* capsule + GRB 35 capsules, POP + *Trichoderma* capsule, POP + GRB35 capsule and POP alone with three varieties namely, Chhattisgarh Haldi 1, Narendra Haldi 1 and BSR 2. The variety Chhattisgarh Haldi 1 performed better and produced 25.45 t/ha and minimum disease intensity of *Colletotrichum* leaf spot (22.78%) and *Taphrina* leaf blotch (20.21%). With respect to the treatments, in POP + *Trichoderma* (talc formulation) + GRB 35 (talc formulation), the yield

was found to be 23.39 t/ha. In the interaction effect, Chhattisgarh Haldi 1 had maximum yield (27.38 t/ha) and disease intensity of 23.4% and 19.61%, respectively. The yield loss assessment by regression models were $Y = 13.68 + (-0.13) \times 1$ and for Taphrina leaf blotch was $Y = 17.4 + (-0.25) \times 1$.

S5 P46

Adaptation strategy to combat climate change effect on chilli production in Tamil Nadu

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Climate change plays as a major game changer in agricultural sector, especially in spice crops which are highly valuable. In the present study, yield projection in chilli until the end of 21st century was carried out to identify the effect of climate change. CCSM4 climate data was downscaled from RegCM 4.4 and used in yield projection till the end of 21st century through DSSAT crop simulation for K1 variety under rainfed conditions in Tamil Nadu. Alternate transplanting dates of advancement and postponement from the default transplanting date were identified and studied for the influence of climate change on yield. The yield projections were defined as near (2011-2040), mid (2041-2070) and end (2071-2099) centuries. The chilli variety K1 responded positively towards advancement of transplanting towards October 15th compared with the usual transplanting date of October 29th. There had been a yield increment by 2.7 per cent, 8.3 per cent and 2.8 per cent in near, mid and end century time scales, respectively. The alternate sowing date can be recommended to farmers after field evaluation to help them in sustaining and excelling the chilli production against climate change effects.

S5 P47

Effect of plant growth promoter on growth and yield of Chillies (*Capsicum annum* L) cv. PKM 1

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India is a leading country in production of chilli in the world, present area under chilli cultivation is about (0.79 million ha) with a production of (1.2 million tonnes) and productivity of about (1.5 t/ha). Active principle for pungency is capsaicin (N-vanillyl-8-methyl-69(c) noeamide). The principle colouring pigment is 'capsanthin'. The present investigation was aimed at determining the effect of foliar application of plant growth promoter on growth and yield parameters of Chillies plants. An experiment was conducted at Horticultural College and Research Institute, Periyakulam. The trial was laid out in a Randomized Block Design (RBD) including eight treatments with three replication to evaluate the effect of plant growth promoter along with water spray control. PKM 1 variety of Chilli was taken as a test crop. The seedlings were transferred to the main field and inorganic fertilizers (N, P and K) were applied uniformly to all the plots. The treatments

were imposed at 15 days interval at three times (15 days after transplanting, flowering and fruit initiation) on the standing crop with varying dosages. Observation parameters like days to 50% flowering, average number of fruits per plant, average weight of fruits per plant green pod yield, Capsaicin content were also recorded. Among the various treatments, RDF (120:80:80 N, P and K kg/ha) + Plant growth promoter (PGP) @1.5 L/ac as top dressing recorded maximum in plant height of 43.6, 53.8 and 73.5 cm respectively at 30, 60 and 90 days after planting, green pod yield of 35.0 t/ha, average number of fruits/plant (167.1), average weight of fruits (479 g) and capsaicin of 0.71% while the water spray recorded the lowest value of 36.0, 49.0 and 68.6 cm respectively at 30, 60 and 90 days after planting, lowest yield of 24.3 t/ha, average number of fruits per plant (138.5) and average weight of fruits per plant (321 g) and capsaicin (0.70%).

S5 P48

Improvement of Ramnad Mundu/Gundu chilli (*Capsicum annuum*) under rainfed condition for yield and quality

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Ramnad Gundu/Mundu chilli is a small spherical shaped chilli mainly grown in Tamil Nadu. Genetic purification technique has been employed through selfing to develop unique shape along with quality. In the present work, 47 Gundu chilli types were evaluated and 5 best types were selected for purification under rainfed condition. The selected best types (PKMCA 08, PKMCA 20, PKMCA 32, PKMCA 38 and PKMCA 38) are under evaluation at Horticultural College and Research Institute, Periyakulam, which will be further used for development of elite Gundu chilli types.

S5 P49

Influence of humic acid and biofertilizers on growth, yield and quality of chillies (*Capsicum annum L*) var PKM 1

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The present investigation was aimed to study the use of humic acid along with biofertilizer application on growth and yield parameters of chillies. The results revealed that, the application of 75% recommended dose of fertilizers (RDF - 120:80:80 N, P and K kg/ha) + biofertilizers (*Azospirillum* + *Phosphobacteria* + Potash mobilizer + VAM) + Humic plus Liquid as soil application recorded maximum plant height of 50.2, 70.2 and 79.5 cm, respectively at 30, 60 and 90 days after planting, average number of fruits per plant (174.09), average weight of fruits per plant (828 g), green pod yield (30.5 t/ha), capsaicin content (0.69%) and B: C ratio of 2.83 followed by application of 100% RDF + biofertilizers (*Azospirillum* +

Phosphobacteria + Potash mobilizer + VAM + Humic plus Liquid as soil application) with a green pod yield of 29.8 t/ha and capsaicin content of 0.62%, while the control recorded lowest yield of 22 t/ha and capsaicin of 0.42%.

S5 P50

Population dynamics of aphids on *Bhut jolokia* (*Capsicum chinense* Jacq.) and evaluation of IPM modules against it in Assam, NE India

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Bhut jolokia (*Capsicum chinense* Jacq.) is an important cash crop of North-East India. Two species of aphids *viz.*, *Aphis gossypii* and *Myzus persicae* were found to be infesting *Bhut Jolokia* and the incidence ranged from 0.45 to 8.45 and 0.20 to 5.26 numbers per three leaves and appeared from 2nd to 4th week of January in *Rabi* season with highest incidence from 2nd fortnight of March to 1st fortnight of April during 2017-18 and 2018-19 and aphid population exhibited significant positive correlation with maximum temperature and significant but negative correlation with average relative humidity. Among the five IPM treatment modules tested, the population of aphids were found to be minimum 0.3/3 leaves in the module I (RDF and FYM + microbial consortium + growth promoter *viz.*, Tricentanol + weeding at 30, 60 and 90 DAT + imidacloprid 17.8 SL @ 0.4 ml per litre at 40 days interval) which was found to be the most effective module with respect to B: C ratio (3.02:1) and maximum aphids, 0.47/3 leaves in module III (vermicompost 1.25 t/ha+ neem cake 500 kg/ha + microbial consortium + black polythene mulching + garlic extract @ 10% at 20 and 70 DAT + NSKE 5% at 35 and 100 DAT + installation of sticky trap @ 25 traps/ha), while in other modules *viz.*, II, IV and V the population were 0.33, 0.41 and 0.39 aphids/3 leaves.

S5 P51

Responses of exotic hot pepper lines to challenge inoculation of chilli leaf curl virus (ChLCV)

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In the present study, in order to identify stable sources of resistance to chilli leaf curl viral disease (ChLCVD), 100 hot pepper accessions from World Vegetable Centre (WVC), Taiwan, consisting of *Capsicum annum*, *C. baccatum*, *C. chinense* and *C. chacoense* were evaluated for disease response by challenge inoculation with ChLCV Guntur strain. The results indicated that, the accessions followed a positively skewed per cent disease index (PDI) values indicating prevalence of resistant alleles to a considerable magnitude. None of the accessions showed immune reactions. However, in contrast to checks; Byadgi kaddi and

Byadgi Dabbi, the accessions, VI012642 (*C. chinense*) and VI059328 (*C. annuum*) expressed resistant reactions while, VI037438 and VI046894 (both *C. annuum*) were identified as moderately resistant as they manifested a fairly low visual symptoms of leaf curling. Since *C. annuum* is cultivated worldwide, VI059328 could serve as a potential resistant source for trait introgression after multi seasonal validation of the source.

S5 P52

Classificatory characterization of some nutmeg (*Myristica fragrans* Hoult) genotypes

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In the present investigation, seedling-based germplasm collection including 38 accessions in the age group 12-15 years were used for classificatory characterization. The study identified sexual variability pattern and morphometric characteristic features of some of the genotypes with commercial as well as crop improvement potentials. The results revealed significant variation among nutmeg genotypes across the population for growth habit, time taken to first flowering (precocity), bearing pattern, nut and mace yield, physico-morphological traits of fruits, seed to mace ratio, per cent shelling etc. The number of fruits per tree varied from 127 (NMA 1) to 3690 (NMD 5). NMD1, NMD2, NMF5, Tamsuli 1, Tamsuli 2 and NMI 1 were identified as superior genotypes for further crop improvement and/or for direct clonal selection for elite types and multiplication.

S5 P53

Identification and characterization of *Lasiodiplodia theobromae* associated with die-back and decline disease of nutmeg

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In the present study, surveys were undertaken in major nutmeg growing tracts of Kerala to study the incidence and distribution of die-back and decline disease. The disease was characterized with external symptoms including general decline of the tree, water soaking symptoms on branches and tree trunk, die back of branches as well as internal symptoms like necrotic lesions on the bark beneath water soaked lesions and necrosis of vascular tissues. The pathogen was initially identified as *Lasiodiplodia* species based on macro and micro-morphological features. Based on analysis of nucleotide sequences of ITS, *EF1- α* and β -tubulin gene regions the pathogen was identified as *Lasiodiplodia theobromae*. The necrotic lesions were developed on twigs, branches and saplings on 10-12, 16-18 and 20-22 days after inoculation, respectively during *in planta* pathogenicity studies. Vegetative compatibility studies revealed that, all the isolates were compatible with each other irrespective of the regions of origin. Microscopical examination revealed the sequence of events in vegetative compatibility including hyphal homing, aggregation at point of contact and formation of anastomosis bridge. Among the fungicides evaluated under *in vitro* conditions, Bordeaux mixture (1%), mancozeb (0.2%) and carbendazim-mancozeb (0.1%) completely inhibited mycelial growth of the pathogen.

S5 P54

Influence of genotypes on flower production in nutmeg (*Myristica fragrans* Houtt.)Sharon Aravind*, K Kandiannan, J Rema & S J Ankegowda¹

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A study was conducted to analyze the effect of genotypes of nutmeg on flowering pattern at ICAR-Indian Institute of Spices Research, Regional Station Appangala. The study population consisted of twenty nutmeg trees (30 years old) selected randomly from the germplasm. The monthly flowering pattern and sex expression of individual trees were recorded from January to December 2015. The study revealed prominent variation in flowering pattern of nutmeg genotypes across the month in a year. Even though, the male flowers were seen throughout the year there was a significant variation among the nutmeg genotypes with respect to male flower production. The genotype IC 548881 produced male flowers throughout the year except during September. The superior male flower producing genotypes like IC 548881 can be used for planting in the orchard to meet the male:female ratio of 1:10. The genotype, IC 548883 produced >50% of flowers examined having female phase in the month of March, June and December. Also, more percentage of female flowers were observed in the genotypes like IC 548905 (86.4%), IC 548883 (85.7%) and NN (83.5%) which implies that these genotypes can be used as a source of scion for the production of grafts. The genotypes *viz.*, IC 548882 and IC 548883 will bear fruits during summer as they produced more female flowers in the month of June that would help to escape the produce from aflatoxin production due to fungal infection.

S5 P55

Studies on leaf rot of nutmeg caused by *Cylindrocladium scoparium*

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During a field visit in August 2019, seedlings planted in polybags were found affected by severe leaf rot disease in a private nursery near Adimali in Idukki, Kerala. The symptoms appeared as dark spots measuring 3-4 mm on the young leaves which later coalesced to form blighted appearance. At maturity, the central regions of the spots appeared brownish. The causal organism possessed dense mycelium, brownish to dark brown in colour with white border and a slightly irregular margin. The pathogenicity was established by inoculating 5 mm mycelial discs of the fungus on the leaves of nutmeg plants and re-isolated the fungus. The lesions were formed after second day of inoculation and completely developed on the fourth day. It produced hyaline septate hyphae, conidiophores with di- or trichotomic branches composing phialides, septate stipe, cylindrical conidia with rounded ends, hyaline and bicellular. The colony grown on PDA was typically light brown with a white border and a slightly irregular margin. The maximum colony diameter (6.6 cm) was noticed when grown on PDA after seven days as compared to HS PDA, YEA, WA, PCA, CYA, CZA and

YES. The fungus was identified as *Cylindrocladium scoparium*. In poisoned food technique, copper oxychloride (0.2%) slightly inhibited the mycelial growth of *C. scoparium*. A perusal of the literature showed that *C. scoparium* has not been previously reported on nutmeg. Hence this paper forms first report of *C. scoparium* on leaves of *Myristica fragrans* causing leaf rot.

S5 P56

Studies on microbial contamination in stored nutmeg and mace

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A study was carried out to determine the extent of microbial contamination in nutmeg and mace. Twenty five samples were collected from different local markets in Idukki and Ernakulum districts of Kerala. The fungal contaminants were isolated by blotter test and agar plate method on PDA and RBA. The fungi isolated from nutmeg and mace samples included *Aspergillus niger*, *A. flavus*, *Penicillium* spp., *Rhizopus stolonifer*, *Fusarium oxysporum*, *Trichoderma*, *A. fumigatus* and a non-sporulating unidentified fungus. The most predominant fungal species found in the samples were *Aspergillus niger*, *A. flavus* and *R. stolonifer*. Estimation of oleoresin content of healthy and affected samples indicated that the quality was deteriorated on long storage.

S5 P57

Study on seasonal variation of growth, flowering and fruiting in nutmeg (*Myristica fragrans* Houtt.)

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The present study on seasonal variation in growth, flowering and fruiting in nutmeg mixed cropped in coconut plantation was conducted under Dapoli conditions of Maharashtra. The flower morphology indicated that hermaphrodite flower was bigger than female and male flowers. All the flowers were bell shaped and cream in colour. The internal structure analysis showed that, male flower had only androphore, female flower only gynoecium while hermaphrodite flower had gynoecium covered by androphore. Female flowers with bilocular ovary was also observed. Maximum number of flowers per shoot was observed in the month of July in all the three types viz., male (12.4), female (1.57) and hermaphrodite (2.78). Whereas maximum percentage of shoots were flowered in the month of July in all the three types. The anthesis started between 8 to 9 a.m. in all the three seasons i.e. rainy, winter and summer. The peak of anthesis was observed between 4 to 5 p.m. and 3 to 4 a.m. in all the three types. Under open pollination conditions, maximum fruit set was observed in the month of November in both female and hermaphrodite. In case of hand pollination, significantly maximum fruit set was observed in summer season. The peak period of fruit harvest was recorded in the month of September.

S5 P58

Bioefficacy of biopesticide and fungicide on per cent disease index of coriander powdery mildew (*Erysiphe polygoni*)

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The present study was carried out during *Rabi* season of 2019-2020 with ten treatments. The treatment combination of two foliar sprays with *Lecanicillium lecanii* 1.15 WP (1×10^9 cfu/g) + spray of Carbendazim 50 WP @ 0.1% (first spray) + spray of Propiconazole 25 EC @ 0.05% (second spray) recorded minimum mean disease index after first spray (3.98 PDI) and after second spray (3.5 PDI) over untreated control (6.23 and 6.15 PDI). Propiconazole was found to be effective in reducing the incidence of powdery mildew and producing higher yield.

S5 P59

Management of coriander powdery mildew using new generation molecules

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A field experiment was conducted under All India Coordinated Research Project on Spices in *Rabi* season during 2015-16 to 2018-19. The experiment consisted of seven treatments including Azoxystrobin 23% SC (0.1%), Propineb 70% WP (0.2%), Tebuconazole 25.9% EC (0.1%), Wettable Sulphur 80% WP (0.2%), Hexaconazole 5% SC (0.1%), Propiconazole 25% EC (0.1%) and untreated control. The analysis of data revealed that, all the fungicides were effective and reduced the disease intensity and increased the yield significantly over the control. The results further revealed that, minimum disease intensity (15.27%), highest yield (15.88 q/ha) and highest B:C ratio of 4.75 was recorded with Hexaconazole 5% SC (0.1%) followed by Propiconazole 25% EC (0.1%). The untreated control had the highest disease intensity (72.06%) and lowest seed yield (11.37 q/ha).

S5 P60

Organic production of leafy coriander in homesteads

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In the present study, an attempt was made to assess the suitability and performance of coriander grown in growbags under organic nutrition. Different sources of nutrients (farmyard manure, vermicompost, arbuscular mycorrhizal fungi) solely and in combinations for nutrient management was compared with the control (chemical fertilizers). The results revealed that the combination, vermicompost + AMF resulted in the highest yield (60.9 g bag⁻¹), significantly superior to the use of sources singly, but on par with farmyard manure + AMF (58.9 g bag⁻¹) and chemical fertilizers (54.6 g bag⁻¹). The yield attributes *viz.*, plant

height, number of branches and leaves per plant were also higher in this treatment. The seed germination to harvest took 52 days indicating the ease in cultivation in homesteads and the possibility for inclusion as break crop in crop rotations.

S5 P61

Screening of coriander genotypes against stem gall disease to identify early cultivars with disease resistance or tolerance: A case study done in Hadoti region of Rajasthan

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In the present investigation 162 coriander genotypes were evaluated for resistance against stem gall (*Promotmyces macrosporus*) in sick plots. Among the genotypes, lowest incidence was recorded in the cultivar ACr 1 (3 PDI) and highest in WFGS16-7 (40 PDI). Genotypes with low disease incidence having PDI less than 15 were PFPS16-15, RKC 147, NDCOR 94, CVTCOR 94, CVTCOR 90, RKCF 28, RKCF 36, WFGS16 12, RKD 18, LCC 233, ICS 3, RKC 35, CVTCOR 75, CVTCOR 84, PFPS16-13, RKCF 24 and NDCOR 110. Early genotypes, which matured in 110-120 days and showed high degree of tolerance (< 20 PDI) were CVTCOR 88, PFPS16-13, NDCOR 110, RKCF 36 and RKD 18. High genetic variation was observed for crop duration and stem gall disease resistance, hence it is suggested that the available genetic variation can be exploited to develop early stem gall resistant cultivars for the Hadoti region of Rajasthan.

S5 P62

Delineation of cardamom production zone beyond boundaries based on climate analogues

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A study was undertaken at ICAR-Indian Institute of Spices Research, Kozhikode to identify ideal ecological niche for cardamom (small and large) that would produce similar yield as traditional centers in the future climate scenario by adopting an approach of climate analogues. Climate analogue tool, a web-based tool developed by the Research Programme on climate change, agriculture and food security (CCAFS) helps to identify, connect and map sites with statistically similar climates across space and time. Rainfall and temperature were the main climate variables for the study under SRES A1B emission scenario. Similarity index with 0.75 to 1.0 delineated as highly likely areas and 0.5 to 0.75 as moderately likely areas for crop cultivation in future (year 2049) with climate change. The geographical coordinates of efficient zones under the crops in India based on relative spread index and relative yield index were used as the input/reference site for finding the analogue sites. For running the analysis of small cardamom, 4 reference sites *viz.*, Idukki, Hassan, Kodagu and Wayanad and for large cardamom 7 reference sites *viz.*, Darjeeling, Zunheboto, Mon, Kohima, Phek, Wokha and Tuensang were used. The results showed 104 newly identified districts as well as 236 taluks for small cardamom and 112 newly identified

districts and 234 taluks for large cardamom. Based on the frequency of states appeared, Karnataka and West Bengal under small cardamom and Karnataka, Manipur, Arunachal Pradesh under large cardamom affirms the possibility of extending the production towards these locations.

S5 P63

Effect of sulphur and bio-regulators on yield and quality of cumin

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A field experiment was conducted for three consecutive seasons during 2013-14, 2014-15 and 2015-16 to evaluate the effect of sulphur and bio-regulators on yield and quality of cumin. The results revealed that, application of sulphur @ 45 kg/ha significantly increased the seed yield over control, 15 and 30 kg S/ha by 23.95%, 16.34% and 5.02%, respectively and foliar application of bio-regulators at vegetative and flowering stages recorded significantly higher seed yield over the control (water sprays). Whereas among the bio-regulators, foliar application of TGA @ 100 ppm at vegetative and flowering stages recorded significantly higher seed yield by 11.44% over the control (water sprays). The highest net returns and benefit: cost ratio (Rs. 93250 and 3.32) was realized in application of sulphur @ 45 kg/ha. Similarly, application of TGA @ 100 ppm at vegetative and flowering stages recorded maximum net returns of Rs. 86120/ha with B: C ratio of 3.12. Maximum oil percentage was also registered with application of sulphur @ 45 kg/ha (3.64%) and foliar spray with TGA (100 ppm) at vegetative and flowering stages (3.62 %).

S5 P64

Organic nutrients and wilt disease management in cumin *Cuminum cyminum*

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A field experiment was conducted at SKN College of Agriculture, Jobner during *Rabi* season of 2015-16 to 2018-19 for the control of cumin wilt caused by *Fusarium oxysporum* f. sp. *cumini* along with organic nutrient management. All the treatments were found effective and reduced the disease intensity and increased the yield significantly over the control. Analysis of the data revealed that, minimum disease intensity (11.08%) and highest seed yield (268.23 kg/ha) were recorded with soil application of vermicompost (2 t/ha) + seed treatment with *Trichoderma harzianum* (6 g/kg) + spray of NSKE (5%) with B:C ratio of 2.29. It was statistically at par with of soil application of FYM (6 t/ha) + seed treatment with *Trichoderma harzianum* (6 g/kg) + spray of NSKE (5%) which resulted in 13.34 per cent disease intensity and 236.59 kg/ha seed yield and B:C ratio of 2.51. The maximum disease intensity (33.26%) and minimum seed yield (141.06 kg/ha) and B:C ratio (1.58) were recorded in the untreated control. The effect of treatments on yield attributing components i.e. plant height, umbels per plant, test weight and blight disease were non-significant.

S5 P65

Screening of effective Zn solubilizing microorganisms from Cumin (*Cuminum cyminum*) rhizosphere

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The present investigation was conducted during 2017-18 and 2018-19 in order to select effective PGPR having zinc solubilizing ability for cumin. During preliminary study, 13 isolates of native Zn solubilizing bacteria were isolated from 21 soil samples of cumin growing fields. Under first stage screening a total of 6 bacterial isolates capable to form bold colonies and clear Zn solubilization transparent zone on zinc solubilizing agar medium were selected for further studies. Based on the halo zone formed by isolates, Zn-solubilization index (SI) was calculated. SI values of these isolates ranged from 1.66-3.00. Zn-solubilization index (SI) after 7 days of inoculation was found highest for isolate of DCU 4 (3.0) followed by 2.83, 2.67, 2.50, 2.17 and 1.66 associated with DCU 10, DCU 3, DCU 7, DCU 9 and DCU 12, respectively. In the second stage screening, selected 6 isolates were tested for acidity (pH 5) and temperature (50°C) tolerance behaviour. Based on the biochemical and morphological tests, all the ZnSB isolates were found to be *Pseudomonas* genus.

S5 P66

Pest's scenario on fennel (*Foeniculum vulgare* Mill.) under organic production system in semi-arid region of Rajasthan

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A trial was conducted to find out the pest scenario on fennel under organic production system. Fennel variety AF 1 was sown in well prepared and statistically laid out field and recommended package of practices were applied for optimum growth of the plants. Regular field monitoring for insect pests were carried out to know the qualitative and quantitative pest status. It was found that, thrips (*Thrips tabaci*, and *Thrips flavus*), jassids, *Empoasca kerri*, whitefly, *Bemisia tabaci*, aphids (*Hyadaphis coriandri* and *Aphis gossypii*), bug, *Nysius* sp. and *Lygus* sp. and chalcid wasp, *Systole albipennis* were the major pests of fennel under congenial environmental conditions. The stink bug, *Nezara viridula*, red cotton bug, *Dysdercus koenigii*, cutworm, *Agrotis* sp., lepidopteran caterpillars and grasshopper, *Acrida* sp., were recorded as minor pests on fennel in winter season crop.

S5 P67

Chemo-profiling of fenugreek genotypes

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In this study, 13 promising genotypes grown at three different locations, which comes under different agro-climatic zones namely semi humid, Pantnagar (AZ 27); semiarid, Jobner (AZ 21) and arid, Hisar (AZ 16) were evaluated for seed yield, diosgenin and galactomannan contents, other phytochemicals, minerals nutrients and antioxidant potential. The bioactive constituents were found to vary in different genotypes apart from being influenced by climatic conditions. The genotypes with high diosgenin and galactomannan contents with respect to agro-climatic zones were identified.

S5 P68

Studies on genetic variability, character association for yield and its attributes in fenugreek (*Trigonella foenum-graecum* L.)

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In the present study, thirty genotypes of fenugreek were evaluated at ICAR-NRCSS, Ajmer during *Rabi* 2018-19. Highly significant differences between genotypes for all the studied traits were observed. The highest genotypic and phenotypic coefficient of variances were observed for seed yield per plant (g) followed by number of pods per plant. The highest genetic advance with high heritability was observed for seed yield per plant (g) followed by number of pods per plant, number of primary branches per plant, number of seeds per pod, number of secondary branches per plant. Seed yield per plant showed significant and positive correlation with number of seeds per pod, number of pods per plant, plant height (cm). Path coefficient analysis indicated that, the highest positive direct effect of plant height (cm) on seed yield per plant (g) followed by number of seeds per pod. It is concluded that, improvement of seed yield in fenugreek is possible through selection for plant height (cm), number of seeds per pod and number of pods per plant.

S5 P69

Studies on the effect of inorganic fertilizers and bio-inoculant (*Rhizobium*, PSB and KSB) on symbiotic properties and yield of fenugreek

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The present investigation was carried out during *Rabi* season of 2019-2020 at Department of Horticulture, JNKVV, Jabalpur. The experimental material comprised of sixteen treatments which were either individual or combination of *Rhizobium*, PSB and KSB with 50, 75 and

100% RDF (30:30:50). The results revealed that, the maximum number of nodules was at 30 DAS (35.07), fresh weight (1 g) and dry weight (0.5 g) i.e. 100% RDF + *Rhizobium* + PSB + KSB. Nutrient (NPK) content in leaves (33.04, 13.51 and 11.11 kg/ha) and seed yield (13.13 q/ha) were found to be maximum with 100% RDF + *Rhizobium* + PSB + KSB.

S5 P70

Physiological evaluation of ajwain crop in climate change scenario of Maharashtra

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An experiment was designed during 2019-2020 with three replications, three dates of sowing and three spacings. During the crop growth period, the observations on parameters *viz.*, plant height, number of branches, days to flowering, number of umbels per plant, number of seeds per umbel, 1000 seed weight and yield per ha were recorded. Significant differences were found among all the parameters. The findings proved to be a new opening in cultivation of ajwain in Marathwada region of Maharashtra under climate change scenario.

S5 P71

Seed spices to combat soil salinity: A thematic approach

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Salt stress is one of the most serious limiting factors for crop growth and production in arid and semi-arid regions. Use of salt tolerant cultivars is an economically viable and environment-friendly approach to obtain stable yields in saline soils. Screening programmes over the years have led to the identification of suitable salt tolerant cultivars in different seed spice crops. From the previous studies conducted at various institutes working on seed spices and on problematic soils, salinity up to 5 dsm⁻¹ had no effect on germination of cumin and cumin crop can tolerate salinity upto 8 dsm⁻¹ without much reduction in growth and seed yield under pot culture. Coriander was resistant to salinity up to 3000 ppm NaCl concentration, fenugreek genotype RMT 303 was found to tolerate up to 80 mM NaCl during germination and early seedling establishment. Selection and further improvement of salt tolerant genotypes/cultivars and varieties may serve as one of the major intervention to improve production and productivity of seed spices under saline environments under climate change scenario.

S5 P72

Assessment of kharif onion varieties in Dewas district of Madhya Pradesh

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In the present investigation, on farm trial on assessment of onion varieties for *Kharif* season was undertaken in farmer's field in Dewas district during 2019-2020. From the study it is revealed that, the variety Bhima Dark Red performed better in both growth and yield parameters compared to Agrifound Dark Red variety. Maximum plant height (58.37 cm), number of leaves per plant (12.31), leaf length (52.11 cm), bulb diameter (6.03 cm), fresh weight of bulb (103.06 g), cured weight of bulb (91.46 g) and bulb yield (229.35 q/ha) were found in Bhima Dark Red. While, neck thickness of bulb (1.17 cm) and bolting percentage (0.00%) were found minimum in Bhima Dark Red. B:C ratio was found very high (13.39) in Bhima Dark Red as compared to Agrifound dark Red (11.94).

S5 P73

Evaluation of different genotypes of garlic (*Allium sativum* L.) under Malwa Plateau of Madhya Pradesh

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A field experiment was conducted with 25 genotypes including 17 local collections and 8 released varieties during *Rabi* season 2018 with the objective to assess the variability for growth, yield and quality parameters and identifying superior genotypes. In addition to this phenotypic and genotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean were studied. Significant variances were exhibited among the genotypes for all the characters studied. Plant height (87.67 cm/plant), dry weight (41.57 g/plant), dry weight of bulb (12.92 g/bulb), neck thickness (1.23 cm/bulb), polar diameter (3.74 cm/bulb), equatorial diameter (4.74 cm/bulb), number of cloves (29.20), clove diameter (1.41 cm), clove length (3.79 cm) and bulb yield (173.04 q/ha) were found highest in genotype G 282. The phenotypic coefficient of variation was higher than the genotypic variation due to influence of environment on the expression of the characteristics. The highest GCV (23.44%), PCV (24.06%), heritability (94.91%), genetic advance as per cent of mean (47.04%) in dry weight gram per plant and genetic advance (28.99 q ha⁻¹) were recorded in bulb yield. On the basis of one year research, it could be concluded that the genotype G 282 was identified to be superior with respect to bulb yield and other parameters for Malwa plateau of Madhya Pradesh.

S5 P74

Evaluation of curry leaf genotypes for genetic variability and quality traits

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In the present study, eight genotypes *viz.*, TPMK 1, TPMK 2, ANMK 3, KMMK 4, KMMK 5, KMMK 6, KMMK 7 and KMMK 8 were evaluated for genetic diversity and quality parameters. Among the genotypes, plant height was highest in KMMK 8 (159.23 cm), number of matured shoots were more in TPMK 1 (6.11), weight of matured shoot was maximum in KMMK 7 (394 g) followed by KMMK 5 (378 g), number of compound leaves were more in KMMK 8 (46.24) and fresh leaf yield was higher in TPMK 1 (878 g) followed by KMMK 5 (852 g). Variation between phenotypic co-efficient of variation and genotypic co-efficient of variation was less for all the characters. High heritability with high genetic advance was recorded in all curry leaf genotypes for the all the parameters. Essential oil content was high in TPMK 1 (1.4%) followed by TPMK 2 (1.25%). In case of aroma compounds, β -caryophyllene was the highest in all the genotypes except ANMK 3 (G-terpinene and β -caryophyllene).

S5 P75

Evaluation of curry leaf *Murraya Koenigii* L. genotypes for yield and quality

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Thirty different curry leaf genotypes along with the check variety Suvasini was evaluated at during 2016-2018 with an objective to select promising genotypes for yield and qualitative traits. Wide variability was recorded for fifteen quantitative and five qualitative morphological characters studied. Among the genotypes, plant height varied from 2.23 m (MK 107) to 5.21 m (MK 103) and more than 40 numbers of tertiary branches were recorded in five genotypes namely MK 107, MK 118, MK 126, MK 142 and MK 160. The leaf length ranged from 14.71 cm (MK 122) to 21.81 cm (MK 126) whereas, maximum number of leaflets (22) were observed in three genotypes *viz.*, MK 126, MK 142 and Suvasini. Harvesting during June-July in the rainy season recorded the highest leaf yield per plant. Leaf yield of more than 5 kg per plant was obtained in four genotypes namely MK 107, MK 126, MK 142 and MK 160. Highest score of 7.4 and 7.33 for flavour and aroma, respectively were recorded in MK 126. Highest essential oil recovery was recorded in dried leaf samples of accession MK 186 (1.09%) and maximum content of crude fiber was recorded in two genotypes namely MK 118 (11.61%) and MK 186 (11.65%). Accession MK 126 recorded the highest content of carbohydrate (15.99%) and protein (6%). Highest content of total phenol (0.31%) and antioxidant capacity (3.45 mg AAE g⁻¹) were recorded in MK 105. The beta carotene content was found higher (\approx 8.80 mg 100 g⁻¹) in three genotypes namely MK 105, MK 142 and MK 186. Considering yield and quality, MK 142 and MK 126 were identified as most promising types followed by MK 105 and MK 186 suitable for Kerala.

S5 P76

Genetic variability, correlation and path analysis of tamarind (*Tamarindus indica* L.)

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Genetic variability, heritability, genetic advance as per cent over mean, correlation coefficient analysis and path analysis were estimated for eleven phenotypic characters of 31 tamarind genotypes. A remarkable variability was observed among the tamarind collection for characters. In all the cases, phenotypic variance was higher than the genotypic variance. In the present study, difference between phenotypic coefficient of variation and genotypic coefficient of variation were found higher for the most of the traits except shell weight, fiber weight, fruit weight and pod yield per tree. The estimate of heritability was found higher in the traits like shell weight (86.19%), fiber weight (89.95%), fruit weight (89.11%), pulp weight (74.13%), number of seeds per pod (62.26%) and pod yield per tree (98.07). In the case of genetic advance as per cent over mean, the traits like shell weight (58.34%), fiber weight (91.96%), pulp weight (51.53%), fruit weight (63.66%) and pod yield per tree (76.1%) also recorded higher than the other characters. Whereas low PCV, GCV, heritability and genetic advance were observed in the traits like pod length, pod width and pod circumference. Regarding correlation studies, pod yield per tree was found to be significantly and positively correlated with pod width, pod circumference and pulp weight. Path coefficient analysis showed that, pod yield per tree has contributed the maximum positive direct effect among the tamarind genotypes.

S5 P77

Performance of elite tamarind genotypes (*Tamarindus indica* L.) for yield and qualities

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In the present study, analysis of variance of mean data collected for a period of 5 years from twenty tamarind genotypes indicated that, there was significant difference in plant height, girth, pod yield, number of pod per tree, pulp yield per tree, length and width. Among the genotypes studied, highest pod yield per tree was recorded in tree number 10 (110 kg/tree) followed by tree number 151 (105 kg/tree) compared to other genotypes. However, the lowest pod yield was recorded in tree number 28 (70 kg/tree). The maximum pulp yield was significantly recorded in tree number 10 (50.95 kg/tree) followed by tree number 51 (36.24 kg/tree) and tree number 14 (33.98 kg/tree). The tree number 22 showed maximum single pod weight (25.09 g), pod length (16.26 cm), pod width (3 cm) and minimum pod weight (13.61 g) and pod width (2.06 g) were recorded in tree number 20, respectively. The plant girth and number of pods were highest in tree number 76 cm, 7387 number) compared to other genotypes. The TSS was highest in tree number 10 (18°B) followed by tree number 51 (17.5°B) compared to other genotypes. Hence, tree number 10 was recommended for

commercial cultivation in southern dry zone of Karnataka under dry land condition as Arsikere tamarind selection (ATS 1) variety.

S5 P78

Performance of tamarind (*Tamarindus indica* L.) collection for pod yield and quality

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In the present study, 31 tamarind germplasm collections were evaluated for yield performance for three years from 2015 to 2018. A significant variation in pod, yield and other pod characters were observed. A wide variation in the number of pods per kg (30.25 g to 52.14 g per kg), pod length (4.8 cm to 16.7 cm), pod circumference (3.1 cm to 7.1 cm), pulp weight (4.4 g to 7.14 g), pod yield per hectare (88.24 to 247.69) and seed weight (2.37 g to 7.20 g) were recorded. A medium variation was also noticed for pod weight (13.87 g to 21.02 g), pod shell weight (2.1 g to 6.74 g), fiber weight per pod (0.63 g to 1.13 g) and number of seeds per pod (4 to 8).

S5 P79

Identification of soil less substrate and host for farm level mass multiplication of arbuscular mycorrhizae

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The present study was taken up to identify a suitable host and substrate for AMF (*Rhizophagus* sp.) inoculum multiplication. Two plant species *viz.*, napier grass (*Pennisetum purpureum*) and maize (*Zea mays*) were evaluated with different substrates, *viz.*, perlite, vermicompost, coir pith, and FYM @ 10% in vermiculite medium on growth and multiplication of *Rhizophagus* sp. The results indicated that, napier grass raised in vermicompost substrate had highest mycorrhizal root colonization (80%) and spore number (135/50 g of the substrate). N uptake was significantly higher in maize plants grown in FYM (2.56 g/plant) followed by napier grass grown in vermicompost (2.01 g/plant). In the case of phosphorus, a significantly higher amount of uptake was observed in both vermicompost and FYM amended napier grass. With the involvement of mycorrhizae, uptake of Mn, Zn, and Cu were also significantly more in napier grass raised in vermicompost. However, uptake of Fe (49.22 mg/plant) was higher in maize amended with vermicompost. Both the hosts (napier grass and maize) amended with FYM showed a significant increase in the shoot length, root length and root biomass over those grown in other substrates. Root colonization positively correlated with root biomass and uptake of major nutrients like nitrogen, phosphorus, micronutrients such as manganese, copper and zinc.

S5 P80

Insecticidal activities of essential oils and their combinations from spice crops against stored grain insect pests in stored wheat and chickpea

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The experiment were conducted to find out insecticidal activities of essential oil from nine spice crops viz., *Cinnamomum tamala*, *Cinnamomum zeylanicum*, *Cuminum cyminum*, *Curcuma longa*, *Foeniculum vulgare*, *Murraya koenigii*, *Myristica fragrans*, *Piper nigrum*, *Syzygium aromaticum*, and their combinations against *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium Castaneum* and *Collasobruchus chinensis* in stored wheat and chickpea for fumigant toxicity and repellency and their effect on germination attributes. In fumigant toxicity test, the essential oils of *C. tamala*, *C. zeylanicum*, *C. cyminum*, *C. longa*, *F. vulgare*, *M. koenigii*, *M. fragrans*, *P. nigrum*, *S. aromaticum* at 0.4 per cent either alone or in combinations of *C. tamala* + *C. zeylanicum*, *C. tamala* + *C. cyminum*, *C. tamala* + *C. longa*, *C. tamala* + *F. vulgare*, *C. tamala* + *M. koenigii*, *C. tamala* + *M. fragrans*, *C. tamala* + *P. nigrum*, *C. tamala* + *S. aromaticum*, *C. zeylanicum* + *C. cyminum*, *C. zeylanicum* + *C. longa*, *C. zeylanicum* + *F. vulgare*, *C. zeylanicum* + *M. koenigii*, *C. zeylanicum* + *M. fragrans*, *C. zeylanicum* + *P. nigrum*, *C. zeylanicum* + *S. aromaticum*, *C. cyminum* + *C. longa*, *C. cyminum* + *F. vulgare*, *C. cyminum* + *M. koenigii*, *C. cyminum* + *M. fragrans*, *C. cyminum* + *P. nigrum*, *C. cyminum* + *S. aromaticum*, *C. longa* + *F. vulgare*, *C. longa* + *M. koenigii*, *C. longa* + *M. fragrans*, *C. longa* + *P. nigrum*, *C. longa* + *S. aromaticum*, *F. vulgare* + *M. koenigii*, *F. vulgare* + *M. fragrans*, *F. vulgare* + *P. nigrum*, *F. vulgare* + *S. aromaticum*, *M. koenigii* + *M. fragrans*, *M. koenigii* + *P. nigrum*, *M. koenigii* + *S. aromaticum*, *M. fragrans* + *P. nigrum*, *M. fragrans* + *S. aromaticum*, *P. nigrum* + *S. aromaticum* at 0.4 per cent (0.2 per cent each) has been found highly effective against *S. oryzae*, *R. dominica*, *T. castaneum* and *C. chinensis* as compared to untreated control in stored wheat and chickpea after eight months of storage. The tested essential oils completely suppressed feeding and breeding of test insects as compared to untreated control. The repellent activities bioassay of *C. tamala*, *C. zeylanicum*, *C. cyminum*, *C. longa*, *F. vulgare*, *M. koenigii*, *M. fragrans*, *P. nigrum*, *S. aromaticum*, at 2 and 4 per cent has been found highly effective against *S. oryzae*, *R. dominica*, *T. castaneum* and *C. chinensis* as compared to untreated control. The tested essential oils from spice crops were able to protect wheat and chickpea up to ten months of storage in super bags against tested insects and they do not affect the germination attributes of stored wheat and chickpea.

S5 P81

Management of isabgul aphid, *Aphis gossypii* Glover through different insecticides under north Gujarat conditions

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In the present study, field experiments were conducted during *Rabi* 2016-17 to 2018-19 to evaluate bioefficacy of different insecticides against isabgul aphid (*Aphis gossypii*). Based

on three year's pooled results, it is inferred that flonicamid 50WG (0.015%) had registered significantly the least aphid infestation (0.48 aphid index) at 7days after second spray and remained significantly superior over rest of the treatments. Mean population of predatory coccinellids showed that untreated control, flonicamid 50WG (0.015%), thiacloprid 21.7SC (0.024%) and thiamethoxam 25WG (0.0084%) had recorded 2.70, 2.12, 1.99 and 1.92 predatory coccinellids/ plant, respectively at 7days after second spray. The plots sprayed with flonicamid 50WG (0.015%) had obtained the highest seed yield of isabgul (1001 kg ha^{-1}) followed by thiacloprid 21.7SC (0.024%) (895 kg ha^{-1}), whereas, unprotected plots of isabgul gave the lowest seed yield (427 kg ha^{-1}) of isabgul. Flonicamid 50WG (0.015%) treated plots of isabgul gave maximum benefit (BCR=1:1.62) followed by thiacloprid 21.7SC (0.024%) (BCR=1:1.42) followed by thiamethoxam 25WG (0.0084%) (BCR=1:1.28) followed by acetamiprid 20SP (0.004%) (BCR=1.10) followed by imidacloprid 17.8SL (0.005%) (BCR=1:0.96). It is concluded that two foliar sprays of flonicamid 50WG (0.015%) (75 g a.i./ha; 3 g/10lit. water) should be made for effective and economical management of isabgul aphid.

S5 P82

On-site DUS testing of farmer's varieties in spices through PPV & FR Act 2001

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DUS testing is a way of determining whether a newly bred variety differs from existing varieties within the same species (Distinctness), whether the characteristics used to establish Distinctness are expressed uniformly (Uniformity) and these characteristics do not change over subsequent generations (Stability). A DUS test is usually conducted in the field or glasshouse over two successive growing seasons. On-site DUS testing is permitted in case of perennial crops. The expert committee constituted by the PPV & FRA in consultation with the DUS Centre will inspect on-site testing and recording of the expression of the characters. Accordingly, field visits or on-site observations of black pepper and small cardamom of farmer's varieties were undertaken from their plots and corresponding reference varieties were identified based on essential characteristics. During 2014-15, applications for six black pepper and nine small cardamom varieties were received for on-site testing and subsequently recommended by the expert committee for registration under PPVFRA. During 2018-19, preliminary observation for the on-site testing of four black pepper and six small cardamom varieties were undertaken.

S5 P83

Use of sulfur nanoparticles as a green pesticide on storage pest *Sitotroga cerealella*

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Biological control strategies to reduce post-harvest losses of food crops due to insect pests could be a viable and sustainable option to increase food production and eradicate hunger. Previous findings have shown that organo-sulfur has insecticidal efficacy against

lepidopteran insect pests like *Sitotroga cerealella*. In the present study, suppression of the moth emergence and reduction in the weight loss of paddy grain (*Oryza sativa* L.) using sulfur nanoparticle synthesized from the bulbs of *Allium chinense* was investigated. The sulfur nanoparticle was characterized using UV-Vis, FT-IR, XRD, EDAX, SEM and TEM. The findings revealed that, the sulfur nanoparticles had a significant effect on the growth cycle (developmental period) from larvae to moth and controlled the weight loss in paddy grain showing toxicity against *S. cerealella*. The present study also revealed that, the sulphur nanoparticle synthesized from *A. chinense* bulb have potential use in integrated pest management of *S. cerealella* for post-harvest protection of paddy considering its availability, abundance and easy propagation.

