National Symposium

Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies

1-3 December 2021

ABSTRACTS

Organised by

Indian Phytopathological Society (South Zone chapter)

in association with

ICAR- Central Plantation Crops Research Institute

Kasaragod, Kerala

NATIONAL SYMPOSIUM ON

SUSTAINABLE PLANT HEALTH MANAGEMENT AMIDST COVID PANDEMIC: CHALLENGES AND STRATEGIES

1-3RD DECEMBER 2021

ABSTRACTS

ORGANIZED BY

INDIAN PHYTOPATHOLOGICAL SOCIETY (SOUTH ZONE CHAPTER)

IN ASSOCIATION WITH

ICAR- ICAR-CENTRAL PLANTATION CROPS RESEARCH INSTITUTE KUDLU.P.O, KASARAGOD,KERALA, 671124, INDIA

National Symposium on

Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies

1-3rd December 2021

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SECRETARY & DIRECTOR GENERAL

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MESSAGE

Ever increasing incidences of plant diseases are, in fact, a serious threat to stable and nutritious food supply chain and food security in many regions around the globe. Currently, plant diseases, including endemic and recently emerging ones, are expanding by several folds, and are exacerbated by climate change. Addressing these challenges posed by disease causing microbes, and further prevention of such outbreaks requires adoption of novel techniques for sustained digital disease surveillance, improved and precise diagnostics, predictive modeling, and data analytics in synergy with ecological intensification and carbon neutrality.

I am quite happy to know that the National Symposium on "**Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies**" being organized through virtual platform during 1-3 December, 2021, jointly by Indian Phytopathological Society (South Zone Chapter) and ICAR-Central Plantation Crops Research Institute, Kasaragod will deliberate these issues, and suggest a way forward. I hope, the Symposium would immensely benefit all the stakeholders and evolve a road map to revitalize plant pathological research in India.

I wish the Symposium all success.

(T. MOHAPATRA)

Dated the 16th November, 2021
New Delhi

डा. आनन्द कुमार सिंह
उपमहानिदेशक (बागवानी विज्ञान)

Dr. Anand Kumar Singh
Deputy Director General (Hort. Sci.)

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MESSAGE

Worldwide plant disease epidemics results in crop yield losses worth millions of tons each year. In order to endow with adequate nutritious food, feed, fibre, and fuel for the expanding world human population from the limited land resources, crop yield losses causec by plant pathogens need to be minimized in the milieu of climate change. There is an urgent need to deploy concerted efforts from all stakeholders for the promotion of integrated disease management, as it incorporates resistant/tolerant varieties, early prediction/detection of plant diseases, and reliable disease diagnosis and assessment in a compatible manner.

I am glad tc know that the National Symposium on "**Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies**" is being organized through virtual mode between 01-03rd December, 2021, jointly by Indian Phytopathological Society (South Zone Chapter) and ICAR-Central Plantation Crops Research Institute, Kasaragod. I am confident that this symposium will provide a platform to deliberate innovative disease management strategies and development of robust diagnostic techniques for reducing the crop losses which in turn reduce the cost of production.

(A.K. SINGH)

Date: 23.11.2021

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डॉ. सुनील चन्द्र दुबे
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Dated:

MESSAGE

I am extremely delighted to understand that the National Symposium on "**Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies**" is being organized through virtual platform during 01-03rd December, 2021, jointly by Indian Phytopathological Society (South Zone Chapter) and ICAR-Central Plantation Crops Research Institute, Kasaragod.

Indian agriculture is greatly challenged by rising human population and climate change. Furthermore, the production potential of crops is confronted by abiotic and biotic stresses under changing climate. Phytopathogens are the greatest bottlenecks compounding in every agro-ecosystem that upsets agricultural productivity. It is therefore paramount to evolve eco-friendly and sustainable disease management options against these plant pathogens safeguarding human and environmental health.

I hope this online platform will open out intense deliberations on emerging plant diseases and develop climate smart and sustainable options for environmentally responsible farming. Recommendations emerging from the symposium would benefit all stakeholders and become a trendsetter for sustainable management of plant pathogens with myriad of clean and green technological options.

I wish the National Symposium a great success.

(Sunil Chandra Dubey)

INDIAN PHYTOPATHOLOGICAL SOCIETY

Division of Plant Pathology,
ICAR-Indian Agricultural Research Institute, New Delhi 110012

Dr. Pratibha Sharma
President, IPS

MESSAGE

Greetings from Indian Phytopathological Society (IPS). At the outset on behalf of the Society and my personal behalf, let us congratulate each other for completing 74 years and entering 75th year of establishment of the Society, which is the celebration year for all of us. I am happy to inform you that to mark 75 years of services to the science & society at India and international level, the IPS is celebrating **the Platinum Jubilee year of Indian Phytopathological Society** which took its birth on 28th February,1947. It gives me proud privilege to welcome all our delegates on this occasion.

It gives me an immense pleasure in complimenting Indian Phytopathological Society (South Zone) and ICAR-Central Plantation Crop Research Institute (CPCRI), Kasaragod for organizing a Virtual National Symposium on "Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies" during 1st -3rd December 2021. This virtual symposium consists of following themes *viz*., epidemiology and population biology of pathogens, advances in plant disease diagnostics, emerging diseases and plant quarantine, disease management: host- plant resistance, chemical, biological control and organizing special sessions on recent advances in diagnostics and management of phytoplasma diseases. The organizers have chosen the rightful combination of the topics at this juncture of post effects of pandemic of COVID-19. The deliberations in the conference will emerge as useful recommendations and proceedings which will further help in formulating plant protection strategies. I wish this event a great success.

(Pratibha Sharma)

Dated: November 29, 2021

Message

Dr. Robin Gogoi
Secretary
Indian Phytopathological Society
New Delhi 110 012

It gives me immense contentment that the South Zone (SZ) of Indian Phytopathological Society (IPS) has organized Virtual Symposium on "**Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies**" and the Annual Meeting of SZ during December 1-3, 2021 at ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala. As we know that a major portion of the crop produce losses is due to the adverse effect of the biotic factors and of these plant pathogens have direct role, and researchers have put tireless efforts to mitigate the problems. Hence, in the symposium, some of the important facets of plant pathology like crop disease diagnostics, pathogen detection, epidemiological factors, populations of various fungal and bacterial pathogens, viruses and phytopalsmas as well as the plant quarantine measures will be addressed. Different approaches of plant disease management covering plant breeding for disease resistance, chemical control and eco-friendly management strategies will be presented and discussed by the delegates. I have learned that a large number of scientists, teachers and research scholars have submitted abstracts of their research papers for presentation in this virtual platform.

I am convinced, there will be close interactions and thorough discussions in every technical session of four themes and in the special session on Recent Advances in diagnostics and Management of Phytoplasmal Diseases. The final outcome of the symposium will facilitate to bring out a functional document with respect to the basic and applied researches which will definitely contribute to the development of agricultural sciences and sustain food security.

I wish my best and hearty congratulation to the organizers and their team members for coming forward to convene the symposium, and also take opportunity to wish the researchers, students and extension workers for their ventures rendered to the greater cause. In advance, I further wish the virtual symposium to be a grand success.

Dated: 28/11/2021

(**Robin Gogoi**)

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Dr. Anitha Karun
Director
Chairperson - National Symposium
IPS South Zone 2021

MESSAGE

It is my privilege to extend a warm welcome to the fraternity of plant pathologists of the south zone as well as young research scholars and students who are pursuing their studies in plant pathology for this virtual National Symposium on "**Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies"** hosted by our Institute from 1-3 December 2021. It would have been my pleasure to meet you all on the beautiful campus of this premier institute if there was no Covid pandemic. However, I am excited to meet you all online and witness the wonderful deliberations on diverse issues related to sustainable plant health management and the latest technologies in the diagnosis and management of plant diseases.

Plant diseases are the major production constraint and are known to cause 15 to 20 per cent loss annually. Plant diseases also pose a serious threat to food and nutrition security in the changing climatic conditions. Regular monitoring and early diagnosis of the diseases and timely application of plant protection measures to prevent the loss due to *Phytophthora* diseases in perennial crops like coconut and arecanut is a major challenge. Realizing this, ICAR-CPCRI is working on developing a surveillance system for early diagnosis of coconut diseases using a UAV fitted with a high-resolution multispectral camera and to evolve smart technologies for protecting coconut palms from diseases. The institute has also initiated exploring the use of UAVs for spot application of fungicides or biocontrol agents for control of *Phytophthora* disease in coconut and arecanut.

Hosting the symposium jointly with the Indian Phytopathological Society (South zone chapter) is a great honour to all of us. I wish all the delegates productive and interesting online deliberations and hope to see you all 'in presence' soon in the coming years.

Date: 29.11.2021.

ANITHA KARUN

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Dr. Vinayaka Hegde
Principal Scientist
Organizing Secretary- National Symposium
IPS South Zone 2021

Message

Plant diseases are the major production constraints to many crop plants and ultimately affect food production and nutritional security. The outbreak of emerging and reemerging plant diseases due to climate change is affecting sustainable agriculture production. Apart from this, the increasing labour and input costs, scarcity of skilled labourers to carry out crop protection operations and changing socio-economic conditions in India are other major issues in protecting plants from diseases. Developing smart farmer-friendly technologies for effective delivery of the fungicides or biocontrol agents to target spots is the need of the hour for effective management of the diseases. This necessitates innovation as well as the adoption of environmentally safer plant protection technologies to produce disease-free crops for the burgeoning population. The repeated lockdowns and restriction of movements during 2020-21 due to the worst-hit COVID pandemic have also hampered many agricultural operations. The virtual National Symposium on "**Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies**" from 1-3 December 2021 is aimed at discussing the progress made by the plant pathologists for existing challenges and also for future strategies. The current compilation entitled "Abstracts" included scientific papers addressing the latest advancements to be deliberated and discussed during this mega event. Apart from scientists, many students have come forward to present their research papers and compete for the Prof. M.J. Narsimhan award contest. I hope this online symposium will be useful for all those who are interested in plant pathology. It is also expected that the experienced and young scientific community will discuss and deliberate on various issues in managing the emerging and re-emerging diseases in the south zone.

It would have been very good if we could organize the symposium offline and meet you all in our beautiful campus. However, because of the prevailing COVID pandemic situation, the symposium is being organized in an online mode. I am sure all of you will enjoy the online scientific deliberations during the Symposium. I profusely thank the Indian Phytopathological Society South zone chapter and Director, ICAR - CPCRI for giving me this opportunity to organize this symposium to take stock of scientific progress in the field of plant pathology and come out with a road map for future research.

VHegde

Date: 29/11/2021

Vinayaka Hegde

VIRTUAL NATIONAL SYMPOSIUM
ON
"SUSTAINABLE PLANT HEALTH MANAGEMENT AMIDST COVID PANDEMIC: CHALLENGES AND STRATEGIES"

Sl. No.	Title	Authors
KEYNOTE LECTURES (14-17)		
KN 01.	Vistas in plant health management during post covid agriculture	Dr. Naik, M. K., VC, KSNUAHS, Shivamogga
KN 02.	Understanding and engineering RESISTOSOME- Opening of new door to crop immunity	Malathi, V. G., Retd. Principal Scientist, ICAR-IARI, Coimbatore -641046
KN 03.	Mycosynthesized nanoparticles mediated resistance in tomato against *Phytophthora infestans* and characterization of defense responsive proteins	Sudisha Jogaiah, J. F. Dastur Memorial Award Winner, Karnatak University, Dharwad, Karnataka
KN 04.	Research advances in phytopathogens of plantation crops	Dr. Vinayaka Hegde, Principal Scientist & Head, ICAR-CPCRI
PLENARY LECTURE (18-19)		
PL 01.	Digital tools in advancing plant health management: the case of "Estimate App" for phenotyping yam anthracnose in West Africa	Kolade Olufisayo and Lava Kumar, P.
TECHNICAL SESSION 1 (20-36) **EPIDEMIOLOGY AND POPULATION BIOLOGY OF PLANT PATHOGENS**		
LEAD LECTURE		
LL 01.	Phytophthora diseases and their impact on horticultural crops in changing climatic scenario	Dr. Chowdappa, P., VC, BESTIU
INVITED LECTURE		
IL 01.	Advances in epidemiology and management of banana diseases	Thangavelu, R.
ORAL PRESENTATIONS		
AO 01.	Zoospore-taxis and encystment-based methods for isolating *Phytophthora* from infested black pepper rhizospheric soil	Karthika, C. S., Biju, C. N. and Jeevalatha, A.
AO 02.	CAZyme repertoire reveals the virulence	Vineeth, V. K. and Shaji Philip

	profile of *Colletotrichum fructicola* causing circular leaf spot disease of *Hevea brasiliensis*	
AO 03.	A comprehensive study revealing fungal virulence factors associated with Corynespora leaf fall (CLF) disease in *Hevea brasiliensis* elucidated by whole genome and transcriptome analysis	Reshma, T. R. and Shaji Philip
AO 04.	Deciphering plant-pathogen interactions employing molecular biology tools in sugarcane	Ramesh Sundar, A., Ashwin, N. M. R., Agisha, V. N., Vinodhini, R. T., Amala Mol, D., Lakshana, K. V., Nalayeni, K., Jeyalekshmi, K., Suraj Kumar Mouriya, Palaniyandi Malathi and Rasappa Viswanathan
AO 05.	Epidemiological understanding of *Phytophthora* stem blight in pigeon pea for prevention and management	Mallikarjun Kenganal, Sushma, P., Pandit Rathod, Muniswamy, S., Rachappa, V. H and Dhanoji, M. M.
AO 06.	Phylogeny, identification and pathogenicity of *Lasiodiplodia* associated with coconut-based cropping system	Prathibha, V. H., Rajkumar, Daliya Mol, Rajesh, M. K., Vinayaka Hegde, Monisha, M. and Sushmitha, K.
AO 07.	Behavioural and physiological variations in whitefly, *Bemisia tabaci* to virus infection in cassava	Harish E. R., Mani Chellappan and Makesh Kumar, T.
E-POSTERS		
AP 01.	Influence of weather parameters on the development of bacterial leaf stripe of arecanut	Nandeesha, K. L. Gangadhara Naik, B. and Suresh Patil
AP 02.	Interaction effects of *R. similis* and *P. capsici* on black pepper	Umashankar Kumar, N., Ravichandra, N. G. and Pankaja, N. S.
AP 03.	Population dynamics of the vector of pigeon pea sterility mosaic disease, *Aceria cajani* Channabasavanna in northern Karnataka	Badugu Manisha, Prema, G. U. and Jamadar, M. M.
AP 04.	Amplicon metagenome sequencing: Key to unlock the mystical realm of endophytic microorganisms in rubber (*Hevea*) clones in response to *Colletotrichum* infection	Soumyamol, V. B. and Bindu Roy, C.
AP 05.	Multigene phylogeny and haplotype	Balanagouda Patil, Vinayaka Hegde,

	analysis: Reveals predominance of oomycetous fungus, *Phytophthora meadii* (McRae) associated with fruit rot disease of arecanut	Manjunatha K. Naik, Shankarappa Sridhara, Hanumappa Narayanaswamy, Thava Prakasa Pandian R. and Shivaji H. Thube
AP 06.	Assessment of spatial structure and risk associated with fruit rot disease in *Areca catechu* L. through geospatial approaches	Balanagouda Patil, Hanumappa Narayanaswamy, Vinayaka Hegde, Manjunatha K. Naik and Shankarappa Sridhara
AP 07	Root colonization studies to elucidate the endophytic association of drought tolerant isolates of *Trichoderma* spp. in black pepper	Vijayasanthi, K. V., Titty Anna Thomas, Shalini, M. and Praveena, R.
AP 08.	Detection of *Ganoderma* spp., causal agent of basal stem rot from different age group of arecanut palms	Bachu Raghavendra, Gangadhara Naik, B.,[1] Naik, M. K., Maheswarappa, H. P., Ganesha Naik, R. and Satish, K. M.
AP 09.	Laccase enzyme activity assay for studying virulence of *Ganoderma spp.* causing basal stem rot in coconut and arecanut	Greena, K. K., Lakpale, N., Vinayaka Hegde, Daliyamol, Prathibha, V. H.
AP 10.	Impact of climate change on occurrence of fusarium head blight of wheat in northern parts of Karnataka	Gurudatt M. Hegde, Kumar, L., Sudheer Kumar, Suma, B., Uday, R., Sudhakar, K. and Suresh, G.
AP 11.	Diversity of fungi isolated from the dung of Tibetan wild ass *Equus kiang*	Kavyashree, K., Sumashri, K. S., Shilpa, N., Sugandha, S., Chauhan, H., Shivanandappa, T. and Janardhana, G. R.
AP 12.	Effect of weather parameters on incidence of leaf rust disease in *Acorus calamus* incited by the pathogen *Uromyces acori* in Karnataka	Swetha, P. and Sundararaj, R.
AP 13.	Morphological and molecular characterization of *Sclerotium rolfsii* isolated from tomato (*Solanum lycopersicum*)	Brindhadevi, S., Thiruvudainambi, S., Devi Shanthini, V., Chandrika, R. and Sivadharshanapriya, R.
TECHNICAL SESSION 2 (37-49) **EMERGING DISEASES AND PLANT QUARANTINE**		
LEAD LECTURE		
LL 02.	Safeguarding Indian agriculture from pandemic situation through effective and stringent biosecurity and biosafety	Dubey, S. C.

INVITED LECTURES		
IL 03.	Emerging vascular prokaryotes in horticultural crops, diagnosis and quarantine importance	Krishna Reddy, M., Venkataravanappa V., Samuel, D. K., Sriram, S. and Priti Sonavanae
IL 04.	Status of pomegranate wilt (*Ceratocystisfimbriata*) and its management strategies	Devappa, V.
ORAL PRESENTATIONS		
BO 01.	Occurrence of rust caused by *Puccinia melanocephala* in sugarcane germplasm	Gopi, R., Mahendran, B., Chandran, K., Nisha, M., Keerthana, K. and Viswanathan, R.
BO 02.	Leaf and pseudostem rots, the rising threats to elephant foot yam cultivation	Veena, S. S., Jeeva, M. L. and Karthikeyan, S.
BO 03.	Cassava root and stem rot, an emerging menace to cassava growers of Kerala	Jeeva, M. L., Veena, S. S., Makeshkumar, T. and Karthikeyan, S.
BO 04.	First report of *Fusarium falciforme* (FSSC 3 + 4) causing root decay of arecanut, *Areca catechu* L.	Thava Prakasa Pandian, R.,' Shivaji Hausrao Thube, Merin babu, Pratibha, V. H., Rajkumar, Priyank, H. M. and Vinayaka Hegde
BO 05.	Re-emergence of *Exserohilum rostratum* causing black spot of coconut for the first time	Daliyamol, Prathibha, V. H., Greena, K., Kamal Kumar, V., Samsudeen, K. and Vinayaka Hegde
BO 06.	First record of a novel begomovirus and satellites associated with leaf curl disease of passion fruit from India	Venkataravanappa, V., Muralidhara, B.M. and Krishna Reddy, M.
E-POSTERS		
BP 01.	Occurrence of leaf blight by *Rhizoctonia solani* in black pepper nursery	Yamini Varma
BP 02.	Occurrence and detection of *Tomato leaf curl New Delhi virus* isolate causing yellow mosaic disease in vegetable gourds of Karnataka	Bhavana, S., Ganesha Naik, R. and Patil, S.
BP 03.	Association of a novel virus belonging to the family *Totiviridae* with plant pathogenic *Colletotrichum gloeosporioides* isolated from cardamom	Megha Das and Bhat, A. I.
BP 04.	First report of natural infection of tomato by *Potato spindle tuber viroid* (PSTVd)	Shilpa, N. and Janardhana, G. R.

	in India	
BP 05.	*Neofusicoccum parvum* causing dieback disease of *Melia azedarach* in Karnataka state (India)	Krupalini, V. and Janardhana, G. R.
BP 06.	First report of *Parthenium hysterophorus* susceptibility to *Meloidogyne hapla* in Nilgiris, Tamil Nadu	Berliner, J., Manimaran, B. and Parvez, R.
BP 07	Isolation, characterization and bio-management of *Villosiclava virens*, a unique flower-infecting fungus causing rice false smut disease in India	Jayalakshmi, K., Alok K. Srivastava, Nazia Manzar, Abhijeet S. Kashyap, Alok K. Singh, Pramod Kumar Sahu, Anil K. Sexena, Raju, J. and Ram Dutta
BP 08.	*Alternaria* leaf spot: An emerging threat to oat cultivation	Boda Praveen and Nagaraja, A.
BP 09.	Dry root rot of pigeonpea: An increasing threat to pulse production due to climate change	Mallikarjun Kenganal, Gururaj, S., Patil, M. B., Sunil Kulkarni and Yenjerappa, S. T.
TECHNICAL SESSION 3 (52-59) **ADVANCES IN PLANT DISEASE DIAGNOSTICS**		
LEAD LECTURE		
LL 03.	Present status on molecular diagnosis, characterization, and management of citrus greening disease (Huanglongbing) in India	Dilip Ghosh
INVITED LECTURES		
IL 05.	On-site real-time detection of plant viruses	Selvarajan, R.
IL 06.	Detection of seed borne fungal pathogens and their control for quality seed production	Niranjana, S. R.
IL 07.	*Fusarium sacchari*, an enigmatic pathogen infects sugarcane with complex epidemiology	Viswanathan, R., Selvakumar, R., Malathi, P., Ramesh Sundar, A., Gopi, R., Nithynantham, R. and Manivannan, K.
IL 08.	Identification and diagnostic assay for viruses infecting major spice crops	Ishwara Bhat, A.
IL 09.	Nano-technological approaches for diagnosis and management of plant diseases	Nargund, V. B., Srikanth, H. N., Vinay, J. U. and Chidananda
ORAL PRESENTATIONS		
CO 01.	Colorimetric closed tube Loop Mediated	Nahla Binth, T. and Smita Nair

	Isothermal Amplification (LAMP) assay for the detection of banana bunchy top virus in banana (*Musa* spp.)	
CO 02.	One step Reverse Transcription Loop Mediated Isothermal Amplification (RT-LAMP) for diagnosis of *Banana bract mosaic virus* in banana (*Musa* spp.)	Midhuna Madhu, K. and Smita Nair
CO 03.	Evaluation of PCR markers for mating type determination in *Phytophthora* spp. infecting black pepper	Fathimath Zumaila, Jeevalatha, A. and Biju, C. N.
CO 04.	Molecular diagnostics of emerging diseases of vegetables in Kerala	Sajeena, A., Deepu Mathew, Jacob John, Dhanya, M. K., Deepthi S. Nair, Sri, T. P., Sudha, B., Meera, A. V. and Shanas, S.
TECHNICAL SESSION 4 (60-67) **RECENT ADVANCES IN DIAGNOSTICS AND MANAGEMENT OF PHYTOPLASMAL DISEASES**		
LEAD LECTURE		
LL 04.	Diagnosis, diversity, transmission and management of phytoplasma diseases in India	Govind P. Rao, Division of Plant Pathology, IARI, New Delhi
INVITED LECTURES		
IL 10.	Genotaxonomy of SCGS phytoplasma achieved through Targeted Hybrid Metagenomic Assemblies of plant microbiomes: *'Candidatus* Phytoplasma sacchari' a case study	Kiran Kirdat, Bhavesh Tiwarekar, Vipool Thorat and Amit Yadav
IL 11.	Phytoplasma *diseases of coconut in India*	Merin Babu, Josephrajkumar, A., Anes, K. M. and Vinayaka Hegde
IL 12.	Association of Phytoplasma-like organism (PLO) in Tapping Panel Dryness (TPD) of rubber (*Hevea brasiliensis)*	Shaji Philip, Edwin Prem, Vineeth, V. K. and Vinoth Thomas
ORAL PRESENTATIONS		
DO 01.	Association of phytoplasma with bud proliferation of vegetable cowpea in Kerala	Devika, S., Radhika, N. S., Joy, M., Sarada, S., Lekha, M., Susha, S. Thara, Gifty, K. J. and Rao, G. P.
DO 02.	Abundance of *Cand. Patescibacteria*: A novel microbial phylum in arecanut rhizosphere in YLD endemic areas	Paulraj, S., Ravi Bhat, Rajesh, M. K., Ramesh, S. V., Priya, U. K., Thava Prakasa Pandian, R., Vinayaka Hegde and

		Chowdappa, P.
DO 03.	Effect of plastic mulching on disease index and yield of yellow leaf disease affected arecanut (*Areca catechu* L.)	Bhavishya, Priya, U. K., Najeeb, N., Thube, S. H., Pandian, R. T. P., Jose, C. T. and Ravi Bhat
E-POSTERS		
DP 01.	Diversity of leaf hoppers in Marayoor sandalwood (*Santalum album* Linn.) reserve affected with sandal spike diseases (SSD)	Manjula, K. N., Padma, S., Kavya, N. and Sundararaj, R.
DP 02.	Molecular screening of citrus germplasm for simultaneous detection of *Candidatus* Liberibacter species associated with citrus greening disease	Amitha Paul, Palash Deb Nath, Rajkumar Kakoti and Munmi Borah
DP 03.	*Candidatus phytoplasma aurantifolia* associated with sesamum phyllody in Kerala	Gifty, K. J., Radhika, N. S., Joy, M., Suja, G., Beena, R., Susha, S. Thara., Devika, S. and Merin, B.
TECHNICAL SESSION 5 (68-105) **DISEASE MANAGEMENT - HOST PLANT RESISTANCE, CHEMICAL AND BIOLOGICAL CONTROL**		
LEAD LECTURE		
LL 05.	Microbiome engineering - A systems biology approach in crop disease management	Dr. Babu S., Professor & Dean, VAIAL
INVITED LECTURES		
IL 13.	Significance of viral diseases of cucurbitaceous vegetable crops in Tamil Nadu and its management through IPM strategies	Karthikeyan Gandhi
IL 14.	Advances in bio-pesticides and its application in field, horticulture and forest crops for sustainable plant disease management	Gurudatt M. Hegde
IL 15.	Advances in breeding for resistance against crop diseases with special reference to soybean varieties in India	Shamarao Jahagirdar, Basavaraja, G. T., Nargund, V. B., Sachin Khedekar, Sharadha, H., Devaraja, L., Kumar Lambani, Gautam Vats, Preeti Teli, Mamata and Kavanshree, K.
ORAL PRESENTATIONS		

EO 01.	Effect of biocontrol agents on growth and development of black pepper infected with *R. similis* and *P. capsici*	Umashankar Kumar, N., Ravichandra, N. G. and Pankaja, N. S.
EO 02.	Biocontrol potential of endophytic bacteria for the management of web blight of cowpea incited by *Rhizoctonia solani* Kuhn.	Siva, M.
EO 03.	Yesteryears in coffee leaf rust disease and management strategies in India	Sudha, M., Santoshreddy Machenahalli, Madhu, S. Giri and Ranjini, A. P.
EO 04.	Biotic and abiotic elicitor mediated induced systemic resistance against pearl millet downy mildew	Chandra Nayaka, S. and Lavanya, S. N.
EO 05.	Characterization of genes encoding for antimicrobial properties of *Bacillus safensis* and evaluation of its biocontrol efficiency against rhizome rot pathogens of turmeric	Praveena, R., Dinesh, R., Srekha, K., Revathy, R., Srinivasan, V., Sarathambal, C. and Subila, K. P.
EO 06.	Navigating complexity to breed for disease-resistant clones of rubber (*Hevea brasiliensis*) by screening germplasm accessions and assessing their genetic diversity using Genome-wide SNP markers	Bindu Roy, C. and Limiya Joseph
EO 07.	Exploring the potential of oil based formulation of *Pseudomonas fluorescens* against *Bipolaris sorokiniana* causing spot blotch of wheat and its quality content	Aditi, Dobhal, Gurudatt M. Hegde, Shamarao Jahagirdar, Kiran Mirajkar and Sudhakar Kulkarni
E-POSTERS		
EP 01.	Antifungal activity of volatile organic compounds produced by *Bacillus cereus* against fruit rot caused by *Colletotrichum truncatum* on chilli	Devi Shanthini, V., Theradimani, M., Brindhadevi, S. and Velprabakaran, S.
EP 02.	Microencapsulation: A novel method to deliver *Pseudomonas fluorescens* for management of soil borne pathogens	Sivadharshanapriya, R., Reshmy Vijayaraghavan and Brindhadevi, S.
EP 03.	Microbial consortia for the management of foot rot of wheat caused by *Sclerotium rolfsii* Sacc.	Priyanka Jadav, Gurudatt Hegde, Shamarao Jahagirdar and Vithal Navi

EP 04.	*In vitro* evaluation of new molecules of fungicides against purple blotch *Alternaria porri* (Ellis) Cifferi of garlic (*Allium sativum* L.)	Vijaykumar, K. N., Shripad Kulkarni, Patil, P.V. and Kambrekar, D. N.
EP 05.	Impact of foliar application of fungicides and biocontrol agents on tomato leaf bacterial community structure revealed by metagenomic analysis	Sumbula, V. and Sainamole Kurian, P.
EP 06.	*In-vitro* evaluation of bioagents against leaf spot of ginger caused by *Phyllosticta zingiberi* Ramakr	Sampritha, S., Pankaja, N. S., Mahadevu, J. and Umashankar N. Kumar
EP 07.	Effect of organic amendments against *Sclerotium rolfsii* Sacc. causing damping off and stem rot of cowpea	Malavika Ram, A. K., Meenakshi Rana, Vinayaka Hegde, Daliyamol, Prathibha, V. H.
EP 08.	Fate of gliotoxin in soil ecosystem and plants and its implication on suppressing soil-borne pathogens	Ramamoorthy, V., Oviya, R., Premalatha, K., Jayalakshmi, R., Sobanbabu, G., Mehetre, S. T. and Theradimani, M.
EP 09.	Antibiosis effect of gliotoxin producing *Trichoderma virens* for the management of dry root rot of blackgram and factors affecting stability of gliotoxin in culture medium, irrigation water and soil.	Oviya, R., Premalatha, K., Soban babu, G. and Ramamoorthy, V.
EP 10.	*In- vitro* and field evaluation of chemicals for the management of bacterial leaf stripe of arecanut	Nandeesha, K. L., Gangadhara Naik, B., Vinayaka Hegde and Ganesha Naik, R.
EP 11.	GC-MS analysis of antimicrobial compounds produced by *Bacillus* spp. against Fusarium wilt of brinjal	Chandrika, R., Theradimani, M., Brindhadevi, S. and Ayyandurai, M.
EP 12.	Efficacy of native *Trichoderma* isolates in managing Fusarium wilt of tomato caused by *Fusarium oxysporum f. sp. lycopersici*	Ajith, C. R., Pankaja, N. S., Umashankar Kumar, N., Mahadevu, J. and Monisha, M.
EP 13.	Screening of minicore collection of pigeon pea against sterility mosaic disease in northern Karnataka	Badugu Manisha, Prema, G. U. and Chandrakanth D. Soregoan
EP 14.	Impact of plant growth regulators in *Phytophthora Hevea* interaction	Shilpa Babu and Shaji Philip
EP 15.	Organic management of *Radopholus similis* infesting banana	Ravichandra, N. G. and Kavitha, T. R.

EP 16.	Evaluation of new chemical molecules against *Meloidogyne incognita* infesting cucumber under polyhouse conditions	Ravichandra, N. G. and Kavitha, T. R.
EP 17.	Biomanagement of root-knot nematode and fungal wilt complex in pomegranate	Kavitha, T. R. and Ravichandra, N. G.
EP 18.	Screening and identification of source of resistance to leaf fleck disease through conventional and quantitative (q) PCR assays	Sanju Balan, Viswanathan, R., Nithya, K. and Anita Cherian, K.
EP 19.	Transcriptomic studies reveal enigma of *Hevea* - *Phytophthora* interaction in tolerant and susceptible clones of rubber (*Hevea brasiliensis*)	Aswathy, C. S., Christy Mariyam Sajn and Bindu Roy, C.
EP 20.	Deciphering deterrence in *Hevea brasiliensis* against *Corynespora cassicola* causing Corynespora leaf fall disease in rubber (*Hevea brasiliensis*)	Ann Tom and Bindu Roy, C.
EP 21.	Modern fungicidal delivery approaches to combat fruit rot disease of arecanut under field conditions	Balanagouda Patil, Hanumappa Narayanaswamy, Vinayaka Hegde, Manjunatha K. Naik and Shankarappa Sridhara
EP 22.	Management of chilli fruit rot caused by *Colletotrichum capsici*	Sharath, M. N., Mesta, R. K., Kareem A., Ajjappalavar, P. S. and Ambresh
EP 23.	Biocontrol potential of native *Trichoderma* spp. against anthracnose/twister disease of onion	Ram Dutta, Jayalakshmi, K., Suresh J. Gawande., Sharath M. N., Vishal S. Gurav and Major Singh
EP 24.	Coffee anthracnose disease and recent management approaches in India	Santoshreddy Machenahalli, Madhu, S. Giri, Ranjini, A. P. and Sudha, M.
EP 25.	Management of cotton leaf spot pathogens, *Alternaria alternata* and *Paramyrothecium roridum* using botanicals	Rajaswaminathan Vairavan, Latha Paramanandham, Harish Sankarasubramanian and Kalaiselvi Thangavel
EP 26.	Salicylic acid induced systemic acquired resistance against *Chilli Leaf Curl Virus* (ChiLCV) in *Capsicum annum* L.	Suveditha, S., Geetha, G. A., Shivashankara, K. S. and Krishna Reddy, M.
EP 27.	Effectiveness of fungicides on the management of sooty mould (*Capnodium* sp.) in cotton	Latha Paramanandham and Rajaswaminathan Vairavan
EP 28.	Bio-efficacy of new fungicide molecules	Ranjini, A. P., Sudha, M., Madhu, S. Giri

	against coffee leaf rust pathogen *Hemileia vastatrix*	and Santoshreddy Machenahalli
EP 29.	Large scale demonstration on the use of *Trichoderma* bio-fungicide for management of chilli wilt	Mallikarjun Kenganal, Sushma, P., Raju Teggalli, Aswathnarayana, S. D., Yeri, S. B., Laxuman, C. and Patil, D. H.
EP 30.	Bio-efficacy of propiconazole 13.9% + difenoconazole 13.9% EC against *Myrothecium roridum* in coffee	Madhu S. Giri, Sudha, M., Ranjini, A. P. and Santoshreddy Machenahalli
EP 31.	Influence of plant nutrients on sheath blight severity in different rice genotypes	Punya, N. S., Kiran Kumar, N., Sanath Kumar, V. B., Yogananda, S. B., Ashoka, K. R. and Mahesh, H. B.
EP 32.	Exploitation of secondary metabolites from endophytic *Trichoderma asperellum* against *Rhizoctonia solani* infecting tomato	Nandan, M., Shridhar, S. H., Mantesh, M., Vinaykumar, H. D., Jahir Basha, C. R., Uma Shaanker, and Reddy, C. N. L.
EP 33.	*In vitro* evaluation of systematic fungicide against powdery mildew pathogen of sandal	Vinayak, V. Pai, Vijaykumar, K. N., Suryanarayan, V. and Venkataravanappa
EP 34.	Testing the efficacy of native isolates of *Trichoderma* sp. against rusts and head scab pathogens of wheat	Uma Maheswari, C., Nallathambi, P. and Priya, D.
PROF. M. J. NARASIMHAN ACADEMIC MERIT AWARD CONTEST (106-114)		
MJN 01.	Epidemiology and management of powdery mildew of okra caused by *Erysiphe cichoracearum*	Ashwini, R. and Amaresh, Y. S.
MJN 02.	Exploring plants and microbes associated volatilomes against damping off caused by *Pythium aphanidermatum* in tomato	Praveen, T., Krishnamoorthy, A. S., Nakkeeran, S., Sivakumar, U., Amirtham, D. and Haripriya, S.
MJN 03.	Identification, multi-genic and teleomorphic characterization of *Bipolaris setariae* causing brown top millet leaf blight in India	Gutha Venkata Ramesh and Palanna, K. B.
MJN 04.	*Bacillus* spp. a powerful tool in managing rhizome rot of banana caused by *Pectobacterium caratovorum* subsp. *caratovoroum*	Dinesh, K. and Ravikumar, M. R.
MJN 05.	Comprehending the complex rubber (*Hevea brasiliensis*) genome through Linkage Mapping and Genome wide	Limiya Joseph and Bindu Roy, C.

	association studies to provide new insights on its disease tolerance mechanism	
MJN 06.	Etiology, epidemiology and management of bacterial leaf stripe of arecanut	Nandeesha, K. L., Gangadhara Naik, B., Vinayaka Hegde, Ganesha Naik, R., Sathish, K. M. and Kalleshwara Swamy, C. M.
MJN 07.	Host- Pathogen interaction between sugarcane and *Colletotrichum falcatum*: unravelling the host defense through biochemical and genomic approaches	Nandakumar, M., Viswanathan, R., Malathi, P. and Sundar, A. R.
MJN 08.	Microbial consortia a novel approach for the management of foot rot of wheat caused by *Sclerotium rolfsii* Sacc.	Priyanka Jadav and Gurudatt M. Hegde
MJN 09.	*Bacillus velezensis* (YEBBR6) promote plant growth and induce defense genes transcript in banana leading to the suppression of *Fusarium oxysporum* f. sp. *cubense*	Saravanan, R., Nakkeeran, S. and Krishnamoorthy, A. S.
MJN 10.	Investigations on epidemiology, molecular characterization and management of *Phytophthora meadii* (McRae) causing fruit rot of arecanut	Balanagouda Patil, Hanumappa Narayanaswamy, Vinayaka Hegde, Manjunatha K. Naik and Shankarappa Sridhara
TECHNOLOGIES DEVELOPED BY ICAR-CPCRI (115-126)		
SPONSORS (127-128)		

KEYNOTE LECTURES

Chairman	:	Dr. Chowdappa, P., VC, BESTIU
Convener	:	Dr. Makeshkumar, T., Principal Scientist, ICAR-CTCRI
Rapporteurs	:	Dr. Merin Babu and Dr. Prathibha, V. H., Scientist, ICAR-CPCRI

KN 02. Understanding and engineering RESISTOSOME- Opening of new door to crop immunity

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Losses due to diseases have been the major constraints in improving crop productivity. In recent years the basic mechanism behind active defense of plants is unravelled. The immobility of the plants and absence of active immune system in the sense we understand for mammals made it more vulnerable to pests and diseases. However in time span of evolution plants have acquired multi-layered system of recognition and countering pathogen attack which can be broadly discussed as immune response. The first layer of immune response is at cell surface level where the pattern recognizing receptors (PRR that include receptor like kinases (RLK) and receptor like protein (RLP), recognize the microbial or pathogen associated pattern (MAMP/PAMP) and recognition triggers active defence. The next line of defences are governed by cytoplasmic receptors encoded by resistance (R) genes , which recognize the specific effectors released by the pathogen and initiate second line of active defence which culminate in hypersensitive response (HR). Majority of these cytoplasmic immune receptors or R gene products are proteins having characteristic nucleotide binding sites (NBS) and leucine rich repeats (LRR) and designated as NLRs.

With the advent of next generation sequencing and genome wide analysis nearly 100 NLR genes have been identified in wide array of plant species. Three different classes can be differentiated on the basis of N-terminal domain with in the NLR family. They are: Type 1 with Toll/Inerleukin-1 receptor like (TIR),type2 with coiled-coil N-terminal domain CC, and Type 3 representing powdery mildew resistance 8(RPW8), all these referred to as , TIR-NLR, CC-NLR and RNLR .Some of the interesting modifications understood are, NLR functioning as pairs , NLRs having integrated decoys, NLR having kinase domains which help in fine tuning resistance responses.

Though large number of NLRs have been characterized and their corresponding effectors are described in detail the exact mechanism of their recognition and activation are not fully understood .In 2019-21, this mystery box has been opened and a working hypothesis has been proposed. Wang et.al. (2019) from China studied the mechanism of action of the coiled-coil NLR ZAR1 (HOPZ-ACTIVATED RESISTANCE 1) of *Arabidopsis* by cryoelectronmicroscopy using the proteins expressed in insect cell lines. The proteins ZAR1, pseudokinase, RKS1and uridylated protein kinase (PBS2) and dATP when allowed to interact, it led to oligomerization and formation of pentamer wheels like structures which they called as RESISTOSOME. The ADP /ATP binding lead to oligomerization, and conformational changes resulting in N-terminal region of ZAR1 forming a funnel like structure associated with plasma membrane. They further demonstrated that such association will initiate gating of Ca channels triggering cell death and disease resistance.

Taking cue from structural similarities between RESISTOSOME and Inflammosomes of mammal system, Duxbury *et al*. (2021) fused TIR domain of several NLRS to the N-domain of NLRC4 (mammalian inflammosome) and studied oligomerization and activation .This fusion between TIR of plant NLR and inflammosome could trigger defence, opening up new strategy of delivery of engineered resistosomes across species and cross kingdom to achieve crop immunity.

J. F. Dastur Memorial Award Winner

KN 03. Mycosynthesized nanoparticles mediated resistance in tomato against *Phytophthora infestans* and characterization of defense responsive proteins

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The current challenges of sustainable agricultural development augmented by global climate change have led to the exploration of new technologies like nanotechnology, which has potential in providing novel and improved solutions. Nanotools in the form of nanofertilizers and nanopesticides possess smart delivery mechanisms and controlled release capacity for active ingredients, thus minimizing excess run-off to water bodies. Moreover, with the advent of rapid evolution of oomycete pathogen lineages, the need for sustainable agriculture practices has become the need of the hour. The late blight of tomato caused by *Phytopthora infestans*, has recently emerged as one such devastating disease in India that led to huge crop losses.

This study aimed to establish the broad spectrum antifungal activity of mycogenic selenium nanoparticles (SeNPs) synthesized from *Trichoderma atroviride*, and characterize the bioactive nanoparticles using UV–Vis spectroscopy, dynamic light scattering (DLS), Fourier transform infrared (FT-IR), X-ray diffraction (XRD), scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS), and high-resolution transmission electron microscopy (HR-TEM). Additionally, in the present work seed priming with mycogenic selenium nanoparticles (SeNPs) for elicitation of resistance against tomato late blight disease is investigated. It also aims to understand the defense responses triggered by SeNPs at cellular, biochemical and transcriptomic levels.

From the results, it was evident that the synthesized nanoparticles displayed excellent *in vitro* antifungal activity against *Pyricularia grisea* and inhibited the infection of *Colletotrichum capsici* and *Alternaria solani* on chili and tomato leaves at concentrations of 50 and 100 ppm, respectively. The SEM-EDS analysis of the bioactive SeNPs revealed a spherical shape with sizes ranging from 60.48 nm to 123.16 nm. The nanoparticles also possessed the unique property of aggregating and binding to the zoospores of *P. infestans* at a concentration of 100 ppm, which was visualized using light microscope, atomic force microscopy, and electron microscopy. In the seed priming experiments, enhanced plant growth parameters were observed in bioactive SeNPs-primed tomato plants as compared to control plants. SeNPs-primed and pathogen inoculated

plants exhibited a significant protection of 72.9 % against late blight disease. The primed plants also recorded a remarkable accumulation of lignin, callose and hydrogen peroxide that serve as the cellular defense over the control plants. Further, an elevated level of lipoxygenase (LOX), phenylalanine lyase (PAL), β-1,3-glucanase (GLU), superoxide dismutase (SOD) corroborated the biochemical defense in primed plants, which was also reflected in the corresponding transcriptome profiling of the genes encoding the enzymes.

Overall, the present study highlights the practical application of SeNPs to manage plant diseases in an ecofriendly manner, due to their mycogenic synthesis and broad spectrum antifungal activity against different phytopathogens. This investigation represents an orchestrated correlation between resistance and defense responses incited by SeNPs against tomato late blight disease, which can be used as nano-biostimulant fungicide in protecting tomato plants.

KN 04. Research Advances in Pathology of Plantation Crops

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Plantation crops play a significant role in the promotion of the agrarian Indian economy. The major plantation crops in the country include coconut, arecanut, oil palm, cashew, tea, coffee, rubber, spices and cocoa. Out of these, coconut and arecanut are the major plantation crops predominantly grown by marginal and small farmers and provide livelihood security to more than 12 million farm families. Diseases and pests pose a constant threat to these perennial palms and cause about 15 to 20 per cent crop loss annually. The modern scientific studies in understanding the diseases of coconut and arecanut began as early as 1905 by Sir E.J. Butler who had first reported and identified the bud rot of coconut caused by *Phytophthora* sp. Subsequently, after the establishment of the Central Plantation Crops Research Institute under ICAR in 1971, systematic investigations were carried out on diseases of coconut and arecanut. The major achievements include pathogen identification, disease diagnostics, molecular characterization, epidemiology and the development of integrated disease management with a focus on eco-friendly approaches to maintain sustainable productivity. Despite decades of intense research on diseases of plantation crops, effective and timely disease suppression is a major challenge in the changing climate and socio-economic conditions. The major diseases of coconut are bud rot, basal stem rot, stem bleeding, root (wilt) and leaf blight whereas, in arecanut, fruit rot, inflorescence dieback, basal stem rot and yellow leaf disease. In recent years, leaf blight diseases caused by *Lasiodiplodia* sp. and *Colletortichum* sp. have emerged as major problems. The re-emergence of bacterial leaf stripe in arecanut is also a major concern. Integrated disease management has been developed and demonstrated area-wide over the years for effective disease suppression. However, early diagnosis and timely application of disease management solutions are difficult to implement due to the tall nature of these palms. Prophylactic application of 1%

Bordeaux mixture is recommended and found effective in reducing loss due to *Phytophthora* diseases namely bud rot and fruit rot in these palms. Alternate fungicides and biocontrol agents have also been identified and found effective in managing these diseases. Application of 5 kg of *Trichoderma harzianum* enriched neem cake per palm and root-feeding with hexaconazole was reported effective in the management of basal stem rot caused by *Ganoderma* sp. Integrated crop management practices are also developed to obtain satisfactory yield even from disease-affected palms in the case of non-lethal phytoplasma diseases like root (wilt) of coconut and yellow leaf disease of arecanut. Though PCR-based techniques for the diagnosis of major diseases are developed, robust field-level early diagnosis is essential for the timely application of control measures. Regular monitoring and surveillance are needed to check the re-emergence of minor diseases and the emergence of new diseases. ICAR-CPCRI is developing an unmanned aerial vehicle (UAV) based monitoring and surveillance system for major pests and diseases of coconut. Pest and disease monitoring through UAV fitted with a multispectral or hyperspectral camera is a new beginning towards digital farming approach using Artificial Intelligence tools. Application of advanced molecular technologies deciphering host-pathogen interaction, use of UAV coupled with AI and IoT for surveillance and early diagnosis of the diseases, automated mechanized devices for smart delivery of biocontrol agents are being strategized for intelligent disease management in the plantation sector.

PLENARY LECTURE

Chairman	:	Dr. Rakesh Pandey, IPS President Elect
Convener	:	Dr. Vinayaka Hegde, IPS South Zone President
Rapporteurs	:	Dr. Daliyamol, IPS South zone Councillor

PL 01. Digital tools in advancing plant health management: the case of "Estimate App" for phenotyping yam anthracnose in West Africa

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International Institute of Tropical Agriculture (IITA), Oyo Road, PMB 5320, Ibadan, Nigeria

Yam anthracnose disease (YAD) caused by *Colletotrichum gloeosporioides* is a major constraint to yam production in West Africa, which is a home for 90% of the global edible yam production. The use of resistant varieties is the most cost-effective approach used for tackling the anthracnose problem. Phenotyping is a vital aspect of screening for YAD resistance, and this is mostly done visually using a severity rating scale. However, this method is dependent on the experience of the rater and sensitive to raters' bias. Digital tools are being employed to overcome the raters' bias and improve accuracy and precision of phenotyping and save time by reducing the drudgery of manual data entry. IITA developed an Estimate ICT App for accurate phenotyping of YAD. The user matches the standard area diagrams of infected leaves provided on the App for precise YAD severity scoring in the field or detached leaf assay performed under laboratory conditions. The disease severity data is obtainable in a CSV format is easily transferable for further analysis to classify yam lines as resistant or susceptible. The Estimate app, usable on iOS or Android mobile phones, is user-friendly, eliminates rater bias, and offers accurate, more precise phenotyping of yam for YAD resistance screening.

TECHNICAL SESSION 1

EPIDEMIOLOGY AND POPULATION BIOLOGY OF PLANT PATHOGENS

Chairman	:	Dr. Pandey, B. K., ADG Horticulture
Co-chair	:	Dr. Ishwara Bhat, A., Principal scientist & Head, ICAR-IISR
Convener	:	Dr. Ramesh Sundar, A., Principal Scientist, ICAR-SBI
Rapporteurs	:	Dr. Sajeesh P. K. and Dr. Sanju Balan, Ass. Professor, KAU

IL 02. Population biology and genetic diversity of wheat powdery mildew pathogen (*Blumeria graminis* f. sp. *tritici*) in India

Nallathambi, P.,[1] Uma Maheswari, C.,[1] Aarthy, B.,[1] Santosh Watpade,[3] Prem Lal Kayshap,[4] Sudheer Kumar,[4] Kumar, A.,[2] Priya, R.,[1] Sureshbabu, K.,[1] Anju Sharma[4] and Rishav Kumar[3]

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[2] ICAR-Indian Agriculture Research Institute, Division of Plant Pathology, New Delhi
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Wheat (*Triticum species*) is the second major cereal crop for the Indian population. Despite the annual wheat production reached up to 110.67 MT during recent years, recurrent incidences of emerging disease like powdery mildew (PM) emerging as challenges for the productivity and quality of wheat grains. Respective biotrophic fungi ie., *Blumeria graminis* f. sp. *tritici* (*Bgt*) becoming one of the most serious pathogen in wheat cultivars. As far as epidemiology is concern, test pathogen prefers a cloudy weather conditions and therefore, PM is major disease in the northern hemisphere, north-western plains and southern and northern hills of India. Massive populations of asexual conidia are dispersed through micro-cyclic infections on susceptible wheat cultivar. We also ascertained the sexual stage known as Chasmotheica (syn. Cleistothecia) both during an active and passive stage of *Bgt*'s life cycle at southern hills (Nilgiris). We also investigated the population biology from an array of 275 *Bgt* isolates which represents three agro-climatic zones (Southern hills, North Western plain and Northern hills zones) of India. For the first time, we explored the host differentials introgressed with 'R' genes (*Pm* genes) to identify the phenotypic diversity among *Bgt* population in our country. Furthermore, *Bgt* population was narrowed down from the phenotypic reactions established under semi-aseptic controlled conditions. Subsequently, the genetic analysis of DNA was performed by using the shortlisted isolates of *Bgt* from core population. Gene specific primers were more precise to identify the highly virulent isolates of *Bgt* population from wheat. To summarize, the combined analysis of phenotypic reactions from the host differentials and genetic data generated through ITS and genes specific primers were efficient for the identification and virulent pathotypes analysis from wheat powdery mildew population. Our new methodologies established in case of wheat powdery mildew pathogen could set the base population biology and genetic studies in powdery mildew pathogens of different crop plants in India.

AO 01. Zoospore-taxis and encystment-based methods for isolating *Phytophthora* from infested black pepper rhizospheric soil

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Phytophthora, the stramenophilic phytopathogen is the most devastating genus pan globe inciting damages to numerous economically important horticultural crops. The rapid dissemination of *Phytophthora* in agricultural systems is mediated through bi-flagellated zoospores and the homing responses of zoospores towards host are profoundly influenced by chemo-electrotaxes mechanisms. Though different methods have been devised to isolate *Phytophthora* from infested rhizospheric soils, studies addressing zoospore taxis and encystment-based methods for isolation is meagre in *Phytophthora*-black pepper host-pathosystem. Hence, the present study was formulated principally to develop methods employing different live and inert baits for isolating *Phytophthora* from infested rhizospheric soils of black pepper. Initially an electrotaxis chamber was fabricated based on previous reports to enunciate the mechanism of zoospore taxis which revealed that, the zoospores were attracted towards positive electrode indicating their anionic nature. Further studies using different baits indicated that, the zoospores were attracted and accumulated at the tip of cowpea radicles which were subsequently used for isolation on modified carrot agar medium. Similarly, the zoospores were encysted on thermocol and impregnated paper discs which were subsequently used for isolating the pathogen. Pure cultures were recovered after incubating the baits on modified carrot agar medium and modified cabin-sequestering method was adopted to purify the cultures in case of bacterial contamination, if any. It is concluded that, zoospore taxis and encystment-based methods employing baits like cowpea, thermocol and impregnated paper discs that are cost effective and consumes lesser time for isolation could be successfully used to isolate *Phytophthora* from infested rhizospheric black pepper soils.

AO 02. CAZyme repertoire reveals the virulence profile of *Colletotrichum fructicola* causing circular leaf spot disease of *Hevea brasiliensis*

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Hevea brasiliensis, commercially cultivated crop for latex production, has been seriously affected by the circular leaf spot (CLS) disease recently. *Colletotrichum fructicola* has been identified as the causal organism of CLS disease in India. CLS disease is much severe from other *Colletotrichum* infection caused by *C. acutatum* and *C. gloeosporioides.* The genetic factors that impact the virulence of the CLS infection are still unknown. Within the *Colletotrichum* species, there exists various genetic polymorphisms as well as varying virulence profiles with diverse

hosts. A deep understanding of the pathogenicity and virulence of *C. fructicola* is required to propose effective control measures. Fungal pathogenic proteins are typically described as effector molecules that can affect plant defence mechanism and temper host immunity. Carbohydrate-active enzymes or CAZymes, are one of the primary types of effectors that interact with plant substrates playing role in carbon acquisition and metabolism in fungi, as well as their heterotrophic lifestyle. Three *Colletotrichum* species were isolated and pathogenicity was determined using extracted fungal toxin. Variation in virulence was observed with species and the most virulent species, *C. fructicola* was selected for whole genome analysis to identify the role of CAZymes and the virulent proteins involved in pathogenicity. The resulting assembly (31 kmer) yielded a total length of 57.46 mb genome (52.7% GC content). About, 16,254 total protein coding genes were predicted using AUGUSTUS. *C. fructicola* produces a number of degrading enzymes, including CAZymes. Annotation of the predicted protein sequences using dbCAN CAZyme database revealed 933 CAZymes, including 390 glycoside hydrolases, 65 glycosyltransferases, 25 polysaccharide lyases, 95 carbohydrate esterases, 303 auxiliary activities and 74 carbohydrate binding modules. This CAZyme information clarifies the CAZyme repertoire in *Colletotrichum fructicola* genome, allowing better understanding of the fungus extending research on CLS disease.

AO 03. A comprehensive study revealing fungal virulence factors associated with Corynespora leaf fall (CLF) disease in *Hevea brasiliensis* elucidated by whole genome and transcriptome analysis

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Corynespora leaf fall disease (CLF) caused by the fungus *Corynespora cassiicola* is a major disease in *Hevea brasiliensis* and severely affecting the growth and yield. The *C. cassiicola* species is genetically highly diverse, but no clear relationship has been revealed regarding the pathogenicity. Cassiicolin, a small glycosylated secreted protein effector, is thought to be involved in the necrotrophic interaction with the rubber tree but some virulent *C. cassiicola* isolates do not have a cassiicolin gene. This study aimed to identify the virulence factors involved in CLF. The genome of a highly virulent *C. cassiicola* isolate (HV) from the rubber tree was sequenced and assembled.

The sequence data was generated and gene prediction was performed for the repeat masked assembly. The predicted gene proteins were BLAST searched against database of fungal virulence factors (DFVF), a comprehensive online database of known fungal virulence factors, which collected 2058 pathogenic genes produced by 228 fungal strains from 85 genera. 1026 proteins of the organism matched against the database with 'e' value <0.0001. 229 proteins are classified as leaf spot associated virulence factors, there are other virulence factors identified to

be associated with plant infections.The genes predicted in whole genome analysis is validated by RNA sequencing and transcriptome analysis.

mRNA sequencing libraries were prepared and de-novo transcriptome was assembled. The assembled transcripts were used to predict protein coding sequences. To identify fungal virulence factors, the protein sequences were searched for homology against DFVF using diamond with e-value threshold 0.00001. 1428 proteins were annotated as virulence factors, of which 565 were classified as plant pathogen related. Majority of the plant pathogen virulence factors belong to leaf spot followed by gray mould. The genomic and transcriptomic analysis revealed that the major virulence proteins are classified as leaf spot-associated virulence factors of the mapped genes which are predominant in rubber.

AO 04. Deciphering plant-pathogen interactions employing molecular biology tools in sugarcane

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Sugarcane is widely cultivated for sugar, fibre, ethanol and a myriad of by-products, also it is viewed as a potential source of energy for the future. *Colletotrichum falcatum* and *Sporisorium scitamineum* are the two important fungal pathogens causing red rot and smut diseases respectively in Sugarcane. Breeding for disease resistance is the most promising option for successful management of diseases in Sugarcane. However due to the complex polyploidy nature of the crop, the inheritance pattern of disease resistance in sugarcane is poorly understood. Application of molecular tools are very promising and provide vital clues in unwinding the enigmatic interaction between sugarcane and these two pathogens, which significantly reduces the crop productivity. Recent advances in metabolomics, genomics, transcriptomic and metabolic modelling offer new opportunities to address this question and generate a system-level understanding of metabolic interactions at the host-pathogen interface. Different domains of "Omics" namely Genomics, Transcriptomics, Proteomics and Metabolomics collectively contribute to decipher the functional genomics component in any plant-pathogen interactions. Unwinding of whole genome sequences, followed by RNA and protein expression profiling has added strength to comprehensively determine how genes can contribute to complex phenotypes. Deciphering host resistance and pathogen dynamics by integrating these various tools of Omics would lead to opening up the interactomics component in sugarcane. Identification of candidate genes coding for disease resistance, pathogen recognition receptors (PRRs), pathogen effectors interacting with host proteins, downstream signalling components, etc. can be accomplished by way of elucidating the plant-pathogen interaction holistically. Overall, the developments made thus far in this area has eventually led to opening up of a broader range of disease management strategies in Sugarcane.

AO 05. Epidemiological understanding of *Phytophthora* stem blight in pigeon pea for prevention and management

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Pigeon pea is a popular pulse crop across many states of central and south India. Its production is next to demand and imports are inevitable to meet the domestic consumption. Constraints such as pests and diseases are major limiting factors in pigeon pea production. Among later, wilt attracted much of the attention for decades and now *Phytophthora* stem blight is overtaking due to its fast spread and continued survival. The current study focused on the epidemiology of *Phytophthora* stem blight in pigeon pea and management. This lesser-known disease has become a major hurdle for the past four years, changing climate and shift in weather factors have influenced much of its lateral and horizontal spread. The disease caused by *P. cajani* is highly influenced by weather factors. Correlating weather factors and stages of the crop has shown the vulnerability of crop during early and peak vegetative stages (20 to 75 days after sowing). High relative humidity (>80%) coupled with favorable temperatures of 20 to 35^0C favored infection, the perpetuation of pathogen and spread of the disease very fast. Rainwater was disseminating disease more widely along with the runoff. Water stagnation for more than 8 to 10 hours in standing crops had more disease incidence (>87%) than normal fields. Frequent rainy days provided an ideal microclimate for easy dispersal and faster infection of the host by the pathogen. Infection was noticed on stem ranging from brown to black specks initially of 2 to 3mm later widened and circled the stem forming long and wide strips, often bulged girdles were noticed at the collar region or above the ground portion. Blocking of vascular bundles ceased translocation of photosynthates and breakdown of stem at girdled portion led to the death of plants causing 100 per cent yield losses in affected plants. Among the different fungicides evaluated, metalaxyl 35 WS (0.3%) spraying focused on stem portions could prevent further proliferation of the disease.

AO 06. Phylogeny, identification and pathogenicity of *Lasiodiplodia* associated with coconut-based cropping system

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Lasiodiplodia theobromae (Pat.) Griffon & Moube is a cosmopolitan phytopathogen possessing a wide host range, which includes tropical and subtropical field and horticultural crops. In coconut, *L. theobromae* causes leaf blight or fruit rot diseases, while in cocoa, it causes charcoal pod rot disease. Recently, novel infection patterns were noticed, which manifested as

spindle rot in below four year old coconut seedlings and as basal rot of fronds in adult palms. In addition, we have also observed dieback symptoms in both cocoa and nutmeg in a coconut-based cropping system. Here, we report the results of studies on the etiology of these novel infections and assessment of diversity among isolates based on morphology, phylogenetic analysis and pathogenicity studies. Thirty-two *Lasiodiplodia* isolates from coconut (20 from leaf blight and fruit rot, 10 from spindle rot and two from frond rot) were purified from infected samples collected from disease prevalent regions of Andhra Pradesh, Kerala and Tamil Nadu and Gujarat states. Out of 20 isolates from coconut leaf blight, 18 were identified as *Lasiodiplodia theobromae* and one each as *L. parva* and *L. psuedotheobromae*. Among the eight from spindle rot, seven comprised of *L. theobromae* and one as *L. iranensis*. Pathogen associated with fronds rot and dieback of nutmeg was identified as *L. theobromae*. All 10 cocoa isolates were identified as *L. theobromae* based on morphological and molecular characterization. Pathogenicity tests demonstrated that all the *Lasiodiplodia* isolates were pathogenic to both coconut and cocoa and further confirmed their cross infectivity on both crops. This study revealed the widespread occurrence of *Lasiodiplodia* and three additional species of *Lasiodiplodia* in the coconut system and warrants the development of IDM strategies for the effective management of the disease.

AO 07. Behavioural and physiological variations in whitefly, *Bemisia tabaci* to virus infection in cassava

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Silverleaf whitefly, *Bemisia tabaci* is one of the most notorious invasive insect pests reported, infesting more than 900 species of plants and spreading more than 200 plant viral diseases. Cassava is one of the important tuber crops cultivated all over the World. Cassava Mosaic Disease (CMD) is the most important limiting factor in its production causing on an average 30-40 per cent reduction in yield. *B. tabaci* is the vector responsible for transmission of *Cassava Mosaic Virus* in cassava, which causes CMD.

Cassava genotypes with varying degree of responses to virus infection were used for studying different kinds of interaction existing between the whitefly and virus. The virus manipulates the behaviour of vector to enhance the transmission efficiency and spread of its own kind. Behavioural and life cycle variation study of *B. tabaci* using six cassava genotypes had shown significant variations in virulent and non-virulent whiteflies. Virus infection in *B. tabaci* altered the dispersal and settling. Speed of movement observed to be maximum at 16.25 cm/s in non-virulent female whiteflies on the genotype CMR-128. Feeding was more by virulent ones in susceptible genotypes, compared to resistant genotypes. Maximum feeding was observed (65 stylet sheaths/plant) in the genotype--H-226 by virulent female, where as minimum (2.67 stylet sheaths/plant) was in the genotype--CMR-128 by virulent female. Maximum fecundity was observed in the genotype--H-226 (87.67 eggs/plant) by non-virulent ones whereas, minimum

was in the genotype--CMR-9 (8.67 eggs/plant) by virulent ones. Non-virulent adult females lived up to 16.07 days in the genotype--H-165, while virulent adult males died after 4.1 days in the genotype--CMR-128. Life cycle of female ranged from 30.77 days (CMR-128) to 21.67 days (H-165), whereas life cycle of male ranged from 27.90 days (CMR-1) to 19.23 days (H-165).

Studying these interactions precisely will help to understand the behavioural and physiological variations in whiteflies and other insects and this information could be a valuable tool to formulate management tactics against different viruses.

AP 01. Influence of weather parameters on the development of bacterial leaf stripe of arecanut

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Bacterial leaf stripe of arecanut is an emerging and serious disease specially in the maidan region of Karnataka and its severity leads to the death of the young plants. The study was carried out to find out the relationship between weather factors and disease development. Meteorological data were recorded at weekly intervals by using PASCO weather sensor. The weather factors had direct and significant influence on the disease incidence and studies revealed that PDI was progressing at linear rate throughout the study period. Coefficient of correlation revealed that the mean maximum temperature contributed maximum (r = 0.82) to disease development compared to other parameters followed by relative humidity minimum (r = 0.64). The coefficient of determination (R2) value for pooled data equation was 0.89. The observed severity of Bacterial Leaf Stripe disease varied from 12.29 to 59.00 and predicted severity varied from 12.89 to 58.68 with difference of -3.55 to 3.81. The model was validated at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India; this study will serves as a scientific basis for establishment of integrated disease management module for the disease.

AP 02. Interaction effects of *R. similis* and *P. capsici* on black pepper

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Disease complex involving nematode and fungi have gained momentum in recent years leading to considerable yield loss. The parameters considered for these studies includes shoot

length, root length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight, per cent yellowing, percent drying, percent drooping percent disease incidence and lesion index. The nematode inoculation was at the level of 1,000 J_2 per pot. Influence of single or sequential inoculation with *Radopholus similis* and *Phytophthora capsici* on plant growth parameter were studied. With respect to shoot length, significant differences were noticed among the treatments. Significantly, highest shoot length was observed in the control (42.60 cm) followed by inoculation with *Phytophthora capsici* alone (36.60 cm). The treatment receiving nematode prior to inoculation with the fungus registered lowest shoot length (20.60 cm).With respect to root length, vines in the untreated control produced maximum root length (34.40 cm) and significantly superior over the rest of the treatments followed by inoculation of *Phytophthora capsici* alone (30.80 cm). Lowest root length (17.80 cm) was observed in the treatment inoculation with *R. similis* prior to inoculation of *P. capsici*. The data on fresh shoot weight revealed that, untreated control treatment registered maximum fresh shoot weight (240.0 g) and were significantly superior over other treatments. Least fresh shoot weight was noticed in the treatment receiving inoculation with *R. similis* prior to inoculation with *P. capsici* (180.20 g).Maximum dry shoot weight was recorded in untreated control treatment (70.60 g) followed by the treatment inoculation with *P. capsici* (66.20 g) and significant difference was observed in between the treatments. Lowest dry shoot weight (45.20 g) was recorded in the treatment receiving inoculation with *R. similis* prior to inoculation with *P. capsici*.

Maximum fresh root weight (61.20 g) was recorded and superior over all other treatments. Lowest fresh root weight (35.40 g) was recorded in the treatment receiving inoculation with *R. similis* prior to inoculation with *P. capsici*. Maximum dry root weight was recorded in untreated control (24.40 g) followed by inoculation with *P. capsici* alone (20.80 g) and these two treatments were on par with each other and superior over other treatments. Lowest dry root weight was recorded in the treatment receiving inoculation with *R. similis* prior to inoculation with *P. capsici* (13.00 g).

AP 03. Population dynamics of the vector of pigeon pea sterility mosaic disease, *Aceria cajani* Channabasavanna in northern Karnataka

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The present investigation to study the population dynamics of the vector, *Aceria cajani* on pigeon pea revealed that the trifoliate leaf and vegetative buds of upper canopy harboured relatively more number of mites (46.89 and 56.80 mites per trifoliate leaf, respectively) when compared to trifoliate leaf and vegetative buds of middle (29.17 and 39.41 mites per trifoliate leaf, respectively) and lower canopies (16.63 and 23.40 mites per trifoliate leaf, respectively) showing that the mite vector preferred upper canopy followed by middle and lower canopies.

Amongst different portions of leaflet, maximum number of mites preferred basal quarter of leaflet (19.27, 14.80 and 10.80 mites/trifoliate leaf in top, middle and lower canopies, respectively) followed by middle (15.63, 11.93 and 9.40 mites/trifoliate leaf in top, middle and lower canopies, respectively) and terminal portions (11.93, 6.80 and 4.70 mites/trifoliate leaf in top, middle and lower canopies, respectively). On different aged leaves, maximum number of mite population was observed on younger leaves (62 mites per trifoliate leaf) followed by middle aged leaves with (40 mites per trifoliate leaf) and older leaves (23 mites per trifoliate leaf). Among standard meteorological weeks, maximum number of mites were recorded at 43rd SMW (30.21 mean mites/trifoliate leaf) and the minimum number of mites were recorded at 34rd SMW (2.09 mean mites/trifoliate leaf). The difference in the population of mite during different meteorological weeks may be due to epidemiological factors.

AP 04. Amplicon metagenome sequencing: Key to unlock the mystical realm of endophytic microorganisms in rubber (*Hevea*) clones in response to *Colletotrichum* infection

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Colletotrichum leaf disease (CLD), caused by *Colletotrichum acutatum* and *C. gloeosporioides*, is one of the major diseases of rubber trees. Endophytes are microorganisms residing within plant cells which have beneficial effects on their host by producing antifungal and antibacterial compounds. As a majority of endophytes cannot be cultured, cultivation-independent approach of analysing such microbes is indispensable. In this study, leaves of CLD tolerant (FX 516) and susceptible (RRII 105) clones were challenge inoculated with *C. acutatum*. Leaf samples were collected at different time intervals and DNA was extracted. DNA from challenge inoculated plants were pooled together and taken as treated sample. PCR amplification of 16S rRNA gene and rDNA-ITS region was performed to identify bacteria and fungi respectively. The amplified product was sequenced through Nanopore sequencing. Results of the study indicated presence of152 bacteria and 792 fungi in total. It was observed that common and unique microbiota of fungi was more in resistant clone challenge inoculated with *Colletotrichum*. In case of bacteria there was no significant difference between the treated and control samples. *Cyanobacteria* possessing plant growth promoting activity was the predominant sub-phylum, which have been reported to produce bioactive compounds. Twenty four bacteria and fourteen fungi identified from this study have been reported as antagonistic endophytes in other crops.This is the first metagenomics approach to uncover *Hevea* endophytic microbial diversity, which contributes to a better perception of endophytes in host-pathogen relationships. Further research is in progress to define each of the identified organisms and discover their relevance in augmenting resistance in rubber.

AP 05. Multigene phylogeny and haplotype analysis: Reveals predominance of oomycetous fungus, *Phytophthora meadii* (McRae) associated with fruit rot disease of arecanut

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An oomycetous fungus *Phytophthora* causing fruit rot is the most devastating disease of arecanut in different agro-climatic zones of Karnataka with varied climatic and topographical profiles. The aim of this investigation was to characterize the diversity of geo-distant *Phytophthora* isolates infecting arecanut using robust morphological, molecular phylogeny and haplotype analysis. A total of 48 geo-distant fruit rot infected samples were collected during the South-West monsoon of 2017-19. Pure culture of the associated oomycete was isolated from the symptomatic nuts and pathogenicity was confirmed and characterized. Colony morphology revealed typical whitish mycelium with stellate or petalloid pattern and appearance with torulose hyphae. Sporangia were caducous, semipapillate or papillate, globose, ellipsoid or ovoid-obpyriform in shape and sporangiophores were irregularly branched or simple sympodial in nature. Subsequent multigene phylogeny (ITS, β-tub, TEF-1α and Cox-II) and sequence analysis confirmed the identity of oomycete as *Phytophthora meadii* which is predominant across the regions studied. We identified 49 haplotypes representing the higher haplotype diversity (hd) with varying relative haplotype frequency (hf). Comprehensive morpho-molecular study confirmed the existence of significant diversity among geo-distant isolates (n=48) of *P. meadii*. The knowledge on population dynamics of the pathogen causing fruit rot of arecanut generated from this investigation would aid in developing appropriate disease management strategies to curtail its further occurrence and spread in arecanut ecosystem.

AP 06. Assessment of spatial structure and risk associated with fruit rot disease in *Areca catechu* L. through geospatial approaches

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Phytophthora meadii (McRae) is a hemi-biotrophic oomycete fungus that infects tender nuts, growing buds, and crown regions resulting in fruit, bud, and crown rots in arecanut (*Areca catechu* L.), respectively. Among them, fruit rot disease (FRD) cause serious economic losses to the growers thereby posing the topmost yield-limiting factor in arecanut. FRD has been known to occur in traditional growing areas particularly malnad and coastal tracts of Karnataka. Devising appropriate management approaches to curtail the impacts of disease requires information on the

spatial structure of risks posed by disease and therefore, this study was designed to determine areas that are most at risk. Point pattern (spatial autocorrelation and Ripley's K function) analysis affirmed the existence of moderate clustering across sampling points and optimized hotspots of FRD were determined. Geospatial techniques like inverse distance weighting (IDW), ordinary kriging (OK), and indicator kriging (IK) were performed to predict the percent severity at unsampled sites. IDW and OK generated identical maps where the FRD was higher as revealed in areas adjacent to Western-Ghats and seashore. Additionally, IK was imposed to identify both disease-prone and free areas in Karnataka. After fitting the semivariograms with different models, the semivariogram with exponential model gave the best fit and using this model information, OK and IK krigged maps were generated. The identified FRD risk areas in our study with a higher probability of disease proportion (>20%) exceeding a threshold level, need to be monitored with utmost care to contain further spread of the disease in Karnataka.

AP 07. Root colonization studies to elucidate the endophytic association of drought tolerant isolates of *Trichoderma* spp. in black pepper

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Different species of *Trichoderma* have the potential to manage soil-borne plant pathogens, promote plant growth and to induce resistance in plants against abiotic stresses. Biotic (diseases and insect pests) and abiotic (drought, salinity, etc.) stresses are considered as major yield limiting factors in black pepper (*Piper nigrum*). In the present study endophytic colonization of drought and temperature tolerant isolates of *Trichoderma viz. T. asperellum* (NAIMCC 0049), *T. erinaceum* (APT1), *T. atroviridae* (APT 2), *T. harzianum* (KL3), *T. lixii* (KA15) and *T. asperellum* (TN3) were studied under *in vitro* conditions. Single node stem cuttings of black pepper (variety: - IISR Thevam) were raised in culture bottles with Hoagland solution under *in vitro* conditions. The plants were inoculated with the spore suspensions of test isolates separately. Root samples were collected from treated and untreated plants at regular intervals, 24, 48, 72h, 3rd, 5th, 7th, 14th, 21st and 28th day after inoculation. Root bits of approximately one cm size were sampled from collected samples and made into four subsets (0-2 cm, 2-4 cm, 4-6 cm, 6-8 cm from the tip of root), then surface sterilized and fixed. Further, the root bits were embedded in paraffin wax, sectioned using semi-automatic microtome, stained with lactophenol cotton blue and observed under stereo microscope (Leica). During the initial stages of the study, pre-germinated conidia of three isolates *viz.*, NAIMCC 0049, APT 2 and KA 15 were profusely observed over the root surface and later the hyphae started entering the root system through the cortex. Intercellular colonization by the mycelium was observed in the cortical zone, later advancing to the vascular system followed by intracellular colonization.

Whereas the isolates, *T. erinaceum* (APT1) and *T. asperellum* (TN3) showed endophytic colonization 5th day after inoculation only. Colonization capacities of the test isolates were compared by counting the number of root segments with colonization verses different root length showed that, the isolate *T. atroviridae* (APT2) colonized the most and the least was observed in *T. asperellum* (TN3). The study showed that the root colonization capacities of drought and temperature tolerant isolates of *Trichoderma* spp. varied significantly in black pepper system.

AP 08. Detection of *Ganoderma* spp., causal agent of basal stem rot from different age group of arecanut palms

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In the current experiment, roots of healthy-looking arecanut palms aged 3 to 9 years were collected from basal stem rot infected arecanut gardens. A total of sixty-five root samples were collected from major arecanut growing districts of Karnataka *viz.*, Shivamogga, Davanagere, Chikmagaluru, Udupi, Uttara Kannada and Dakshina Kannada Districts. DNA was extracted from all the root samples using the 2% CTAB method. After confirming DNA in the samples, they were subjected for amplification by using *Ganoderma* specific primers – *Gan* 1 (5'- TTG ACT GGG TTG TAG CTG -3') and *Gan* 2 (5'-GCG TTA CAT CGC AAT ACA- 3') (Utomo and Neipold, 2000) which were designed from Internal Transcriber Spacer (ITS) region 1 of rDNA of *Ganoderma boninense*. Out of all sixty-five samples tested, amplification was observed at 167 bp from the roots of arecanut palms ranging from six to nine years. The pathogen was detected from the roots of six, eight, and nine-year-old palms. This indicates that the pathogen can able to infect arecanut palm with the age of six. Whereas, among the root samples tested, the pathogen was not detected from three to five-year-old palms. This may be because the samples collected are free of *Ganoderma* infection, or the young palms might have ability to resist the invasion than older plants by *Ganoderma*.

AP 09. Laccase enzyme activity assay for studying virulence of *Ganoderma spp.* causing basal stem rot in coconut and arecanut

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Basal stem rot is one of the major diseases in coconut and arecanut responsible for severe yield losses in southern India, caused by *Ganoderma lucidum* and *G. applanatum*. *Ganoderma* are wood-rotting basidiomyceteous fungi which are the most efficient lignin degraders in nature. Lignin is a barrier to microbial attack, provides strength, and is a water impermeable seal across cell walls in the xylem tissue. White-rot fungi produce enzymes such as laccase which are capable of producing strong oxidants to break the structure of lignin in the wood, which allows access to the energy-rich cellulose. Considering the importance of cell wall degrading enzymes in the uptake of nutrients from plant host, these hydrolytic enzymes are considered as the key pathogenicity determinant among plant pathogens. Lignin degrading activity of 30 isolates of *Ganoderma* obtained from different hosts viz., coconut and arecanut were tested qualitatively as well as quantitatively. Qualitative estimation for determining the production of laccase by different isolates were carried out on czapek dox medium amended with different laccase substrates such as guiacol and ABTS showed positive results. Quantitative estimation of laccase activity was done spectrophotometrically with ABTS as substrate at 3 different time intervals showed that maximum absorbance was showed by isolate Coconut PKD (2) and Arecanut 6 isolates from coconut and arecanut hosts respectively at 6 days after inoculation. Those isolates which showed more absorbance showed rapid degradation of root bits as compared to isolates with less absorbance.

AP 10. Impact of climate change on occurrence of fusarium head blight of wheat in northern parts of Karnataka

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The production of wheat in India is affected by several biotic and abiotic stresses; among biotic stresses, diseases such as Fusarium head blight is a worldwide wheat disease caused by *Fusarium graminearum* that significantly affects yield and grain quality. The direct losses due to FHB are reduced yield and test weight due to the presence of Fusarium damaged kernels (FDKs). The indirect impacts of the disease are the trichothecene mycotoxins, which are accumulated in

the kernels during the infection process. The recent outbreak of Fusarium head blight disease during rabi 2020-21 in parts of northern Karnataka is clear indication of climate change. In early sown (II fortnight of October to first fortnight of November 2020) crop at Belgaum and Bagalkote districts the severity of Fusarium Head Blight (FHB) was ranged from 30-40 percent and in Dharwad the incidence was 5-10 Percent in most of the farmer's field. The infected spikes were subjected to laboratory analysis and found typical pinkish colonies of the Fusarium on the PDA media and curved septate conidia were observed under the microscope. In Belgaum district (Arabhavi, Kallolli, Chikkodi, Rayabagh Hukkeri) the abnormal rains coupled with long wetting period of 3-4 days & Temperature 25-270C during January 2021 (anthesis stage) has caused earhead infection (head scab) in bread wheat, durum wheat and dicoccum wheat. The rainfall of Dharwad during incidence was 10-13.5mm, RH of 40-60%, max Temp 30.0-34.00C, Min temp 12-160C While, in Belgaum district rainfall of 10-1102mm, RH of 41-63%, Max temp of 29.0-33.50C, Min temp of 12.0-17.00C and in Bagalkote district 5-7mm rainfall, RH of 40-60%, Max Temp of 30.0-34.00C and Min Temp of 12.0-17.00C was recorded. Most of the farmers in Belagavi district take up maize during kharif followed by wheat in rabi season. During the season farmers were not able to prepare the land due to continuous rains and went for wheat sowing. The improper tillage and stalk rot problem in maize caused by *Fusarium* species coupled with favorable weather during booting stage might be the reason for head scab disease in wheat. This signifies the role of weather and incidence of Fusarium head blight of wheat.

AP 11. Diversity of fungi isolated from the dung of Tibetan wild ass *Equus kiang*

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Coprophilous fungi are a saprophytic dung-loving group of which are fungi largely found in herbivore dung as it is a good substrate for the production of fungi. They are unique in terms of their metabolism and physiology which makes them reservoirs of enzymes and many bioactive metabolites. Studies that have been carried out in many countries all around the world have revealed the coprophilous fungal diversity and their succession on the excreta of various animals such as sheep, horse, cow, roe deer, rabbit, hare, elephant, and toad. But, limited research has been reported from India. In this study, the dung of the largest ass of family Equidae, endemic to the Tibetan and Himalayan valleys which is an extremely cold environment habitant, the Tibetan wild ass (*Equus kiang*) dung was examined for the diversity and succession of microfungi using different incubation methods. A total of eight coprophilous fungi namely *Chaetomium globosum*, *Cladosporium anthropophilum*, *Fusarium equiseti*, *Penicillium steckii*,

Sordaria fimicola, *Talaromyces pinophilous*, *Trichocladium pyriforme* and *Torula chromolaena* were isolated and identified based on morphological and molecular techniques. A phylogenetic tree was constructed for each species to confirm their evolutionary relationship. As *Kiang* is an extremely cold environment inhabitant and has specialized physiological and metabolic adaptations, the association of these fungi in the gut of *E. kiang* plays a key role in gut physiology. Further, the biotechnological applications need to be explored as coprophilous fungi are good reservoirs of enzymes and secondary metabolites.

AP 12. Effect of weather parameters on incidence of leaf rust disease in *Acorus calamus* incited by the pathogen *Uromyces acori* in Karnataka

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Acorus calamus L. or sweet flag is a globally distributed species in the North temperate hemisphere, tropical Asia, and recorded throughout India. Its rhizomes are utilized for treating numerous ailments. In 2018, a severe rust disease caused by *Uromyces acori* affected *A. calamus* plantations in Tumkur, Karnataka. The highest disease index of 69.4 % was observed in December2018, causing severe yield loss to the farmers. The correlation studies of weather parameters indicated that minimum temperature, number of rainy days, and total rainfall showed a significant negative correlation. The multiple regression equation reveals that all the weather factors combined accounted for more than 90% variation in disease incidence. However, minimum temperature accounted for more than 49% variation in disease index having a significant effect on the prediction of the disease index. However, fitting full model regression to the data, we obtain r^2=0.901 and adjusted r^2=0.764. The overall analysis of variance revealed that the mean square due to regression is highly significant.

AP 13. Morphological and molecular characterization of *Sclerotium rolfsii* isolated from tomato (*Solanum lycopersicum*)

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Tomato (*Solanum Lycopersicum*; *Solanaceae* family) which is grown and consumed worldwide has very important nutritional high value added and economic value. It is one of the largest areas and most widely planted vegetable crop production wise China positioned first place. Tomatoes provide unique nutritional advantages, including vitamin C, β-carotene, carotenoids, lycopene, potassium, fiber, flavor, color and antioxidant properties in a low energy

dense food .Tissue from the sampled tomato plants was used for the isolation and identification of the infecting fungal species using microscopic morphology characterization. Final confirmation of the pathogen was performed with PCR amplification and sequencing using fungi specific and sclerotium species – specific primers. Phylogenetic analysis revealed that the *Sclerotium* isolates were grouped into a single clade. Pathogenicity tests conducted with seedlings proved that all the isolates could cause the disease symptoms, but with different degree of virulence. Concerning morphological studies, among the seven isolates of *S.rolfsii*, the isolate S- ALN produced the highest number of sclerotia (146.3 per plate) followed by S-CKU (116.6). Apart from this, the maximum test weight of sclerotium (0.63mg) and the highest oxalic acid production (4.1mg/ml) were also recorded in the isolate S- ALN.

TECHNICAL SESSION 2

EMERGING DISEASES AND PLANT QUARANTINE

Chairman	:	Dr. Niranjana, S. R., Prof & Chairman, University of Mysuru
Co-chair	:	Dr. Nallathambi, P. Principal Scientist, ICAR-IARI, Wellington
Convener	:	Dr. Joy, M., Professor, KAU
Rapporteurs	:	Dr. Jeevalatha, A. and Dr. Biju, C. N., Scientist, ICAR-IISR

LL 02. Safeguarding Indian agriculture from pandemic situation through effective and stringent biosecurity and biosafety

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Biosecurity is a strategic and integrated approach encompassing policy and regulatory frameworks to analyse and manage risks in the sectors of food safety, animal life and health, and plant life and health, including associated environmental risk. It is a holistic concept of direct relevance to the sustainability of agriculture, food safety, and the protection of the environment, including biodiversity.In an agricultural context,biosecurityrefers to the preventive and mitigative measures designed to reduce the risk of transboundary and in-country movement of pests in crops and livestock, quarantine pests, invasive alien species and genetically modified organisms.Agricultural biosecurity has emerged as a solution requiring both policies and technological capabilities to prevent, detect, and quickly respond to any 'Covid- like' Pandemic threats to agriculture. In India, crop production is at risk from exotic pest attack mainly due to free trade of agricultural commodities under Word Trade Organization. In addition, unrestricted movement of people and commodities within and across borders has led to introduction and spread of many new pests in India. Enormous losses amounting to billions of rupees are caused by endemic pests as is evident even from the conservative estimates made for specific areas and pests. Agricultural biosecurity has emerged as solution requiring both policies and technological capabilities to prevent, detect, and respond to such threats. Plant quarantine is a government endeavor to prevent the entry and establishment of exotic pests into the country. To comply with the requirements under the International Plant Protection Convention and World Trade Organization to which India is a signatory, the Plant Quarantine (Regulation of Import into India) Order, 2003 has been legislated and came into force from April 1, 2004, under which import of commodities, additional declarations for freedom from quarantine pests is based on a standardised pest risk analysis.

Biosafety is usually defined as the discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. The practice of safe handling of pathogenic micro-organisms and their toxins in the biological laboratory is accomplished through the application of containment principles and the risk assessment. Thus, biosafety is the application of safety precautions that reduce a laboratorian's risk of exposure to a potentially infectious microbe and limit contamination of the work environment and, ultimately, the community. Therefore, biosafety is the prevention of large-scale loss of biological integrity, focusing both on ecology and human health. Biosafety is the containment principles, technologies and practices that are implemented to prevent unintentional exposure to pathogens and toxins, or their accidental release. Regular reviews of the biosafety in laboratory and following strict guidelines are the preventive mechanisms. National biosafety framework (NBF)

is a combination of policy, legal and technical instruments that is developed to address safety issues with respect to environment and human health in the context of developing and applying modern biotechnology or other biohazardous biological agents. An effective NBF should have the following elements to ensure implementation and compliance. The overall biosafety concept needs tobe updated under changing risk situation, especially if new working methods are adopted, new organisms are handled, new items of equipment which are relevant to biological safety are introduced, existing facilities replaced/ changed.

IL 03. Emerging vascular prokaryotes in horticultural crops, diagnosis and quarantine importance

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Diseases associated with phytopathogenic fastidious prokaryotes occur worldwide in many crops, although individual pathogens may be limited in their host range or distribution. Most phytopathogenic bacteria invade their host plants through natural openings or wounds, colonizing intercellular spaces, expressing virulence factors and inducing various host plant responses. A few, however, are introduced directly into the sugar-rich phloem sieve tubes or into the water-transporting xylem elements by vascular-feeding insects. Due to their vascular habitat, the endogenous bacteria have a systemic distribution throughout the plant, they are transmitted from plant to plant by graft inoculation, and most of them are vectored by insects which feed in the phloem (leafhoppers, psyllids), or the xylem (sharpshooters). These bacteria employ unusual and sometimes unique strategies by which to optimize their niche occupation and obtain their nourishment from the host plant. Their location within living (sieve tubes) or degenerated (xylem elements) plant cells, rather than in intercellular spaces, offers different challenges and opportunities for them to avoid the host plant's defense system. The plant vascular-inhabiting bacteria establish intimate relationships with host and insect vectors. The vascular-colonizing bacteria can be divided into three groups: wall-less mollicutes (phytoplasmas and spiroplasmas), walled phloem-inhabiting bacteria, and walled xylem-limited bacteria. Fastidious prokaryotes are those that either resist to grow in any available mediums, such as phytoplasmas, *Ca.* Liberibacter spp., and *Ca.* Phlomobacter fragariae or those that require specific and enriched mediums, such as spiroplasmas, *X. fastidiosa, Leifsonia xyli* subsp. *xyli*, *L. xyli* subsp. *cynodontis* and *Clavibacter michiganensis* subsp. *sepedonicus.* Based on the inhabitant, *X jastidiosa, Leifsonia* spp. and C. *michiganensis* subsp. *sepedonicus* are xylem-inhabiting while spiroplasmas, phytoplasmas, *Ca.* Liberibacter spp., and *Ca.* Phlomobacter fragariae are phloem inhabiting prokaryotes. Phytopathogenic fastidious prokaryotes associated diseases are spread worldwide, and in several cases are associated with severe epidemic of very often quarantine importance.

The spread of transboundary plant pests and diseases has increased dramatically in recent years. Globalization, trade and climate change, as well as reduced resilience in production systems due to decades of agricultural intensification, have all played a part. The establishment of electron microscopy (EM) based techniques represents an alternative approach to the traditional indexing procedure for phytopathogenic fastidious prokaryotes. Detection is now routinely done by different nucleic acid-based techniques on polymerase chain reaction (PCR). The application of the most commonly used PCR approaches to prokaryotes ranging from classical PCR to several PCR-based detection methods: random amplified polymorphic DNA (RAPD), 16S rDNA polymorphism, quantitative real-time PCR (qRT-PCR), nested PCR (N-PCR), immunocapture PCR (IC-PCR), short sequence repeats (SSRs, also called VNTR), single nucleotide polymorphisms (SNPs), multilocus sequence typing (MLST) and HTS. Application of these techniques for the distribution of phytopathogenic fastidious prokaryotes, indexing of planting material and certification of tissue culture plants for export will be discussed.

IL 04. Status of pomegranate wilt (*Ceratocystisfimbriata*) and its management strategies

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Pomegranate wilt disease incited by *Ceratocystis fimbriata* Ell. And Halst. is adversely affecting pomegranate cultivation in all major growing regions of Karnataka.The severity of wilt of pomegranate in major pomegranate growing regions of North Karnataka was assessed during *kharif* 2016 and maximum wilt (42.10%) incidence was observed in Babaleswar village (Shruthi *et al*., 2019); and (45.16%) was noticed in Besigeger village of Bellary district (Sonyal *et al*., 2016); (45.80%) wilt was observed in Govindkoppa village during 2015-16 (Somu *et al*., 2018). Whereas, (Raja *et al.,* 2017 reported that, highest incidence (33.34%) was recorded in Sirataluk of Tumakur district and (71.12% incidence was noticed in Neerbudihal village of Bagalkot district (Madhushri *et al.,* 2019). Among the various culture media used, oatmeal agar and Potato dextrose agar were excellent media for good growth of *C. fimbriata*. The highest reduction percent of wilt incidence was observed in Trichoderma plus, neem cake and neem cake + Trichoderma plus in pot culture experiment under glass house condition (Tirmali *et al*., 2018). *Ceratocystis fimbriata* grew well in all most all hydrogen ion (pH) concentration from 2.0 to 11.0. (Sonyal *et al.,* 2015).Black colored perithecium which measure 5.13 x 4.27 µm. Endoconidia were hyaline, cylindrical and average size was 23.6 x 4.90 µm. Aleurioconidia were thick walled ellipsoidal or pyriform with size of 18.5 x 10.10 µm. (Raja *et al.,* 2015).Eleven bioagents were evaluated *in vitro*condition,among the bio agents tested, *Trichoderma harzianum*, *Trichoderma* isolate 1 and *Trichoderma* isolate 5 recorded the maximum percent inhibition of mycelial growth (100%). (Karakalamatti *et al*., 2019).The plant extracts *Allium sativum* (32.96%) was found effective in inhibiting mycelial growth (Sonyal *et al.,* 2015).The pathogen being soil borne preventive measures are of prime importance to manage this disease. Among the different systemic fungicides tested, cent per cent inhibition of mycelial growth of *C. fimbriata*

was recorded in propiconazole. Among the different bio agents tested against *C. fimbriata, T. harzianum* was found to be the most effective with the highest inhibition of mycelial growth (88.77 %) followed by *T. viride* (86.60 %) and *P. fluorescens* (66.33 %). *Bacillus subtilis* was found less effective with (54.88 %) inhibition (Khan *et al*., 2017).

BO 01. Occurrence of rust caused by *Puccinia melanocephala* in sugarcane germplasm

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World largest collections of about 3373 sugarcane germplasm and allied genera are maintained at ICAR-Sugarcane Breeding Institute, Research Centre, Kannur. Germplasm clones were monitored for three consecutive years (2018-2020) for occurrence of various diseases. Among the diseases, rust caused by *Puccinia melanocephala* is one of the very important diseases of sugarcane observed in germplasm. Only three clones IJ 76 501, Sylva, 28 NG 211 of *S. officinarum* were affected during study period. Maximum disease score of 7 was recorded on IJ 76 501. In *S. spontaneum* only four clones IND 81-20, IND 81-74, IND 81-82, and IND 81-83 were affected. No incidence of rust was observed in *S. barber*i, *S. sinense* and *S. robustum*. Hybrid clones were most affected than species clones. During 2018, eight clones of foreign hybrids were affected out of 614 clones and twenty two Indian hybrids were affected out of 1031, with the maximum score of 5 recorded in Co 361 and Co 508. Total 26 clones of Indian hybrids were affected during 2019. The incidence was maximum in Co 376, Co 377, Co 699, Co 62161, CoS 568. During 2020 only four clones POJ 279, Co 300, Co 302, and Co 986 of hybrids were affected. Disease appeared in August and September months and decrease in incidence was observed in December. Morphological characters of clones such as, height of the plants, leaf colour, canopy type, leaf length and width, leaf numbers and brix were correlated with disease incidence and found nonsignificant.

BO 02. Leaf and pseudostem rots, the rising threats to elephant foot yam cultivation

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Tropical roots and tuber crops play a significant role in food security by contributing to the energy and nutrition requirements of people. Cassava, sweet potato, yams and aroids are the major tropical tuber crops. Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson is basically a crop of South East Asian Origin. In India, elephant foot yam (EFY) is traditionally

cultivated in the states of Andhra Pradesh, Gujarat, Maharashtra and Kerala. Collar rot caused by *Sclerotium rolfsii* Sacc. and Dasheen mosaic disease are the most common diseases in all EFY growing areas. Recently, there is an upsurge in incidence of leaf blight/ leaf rot in this crop. The disease is seen in all stages of the crop, the symptom start as either spot or blight, spread fast and cause severe foliage rotting on advancement of disease. Different kinds of spots/ blights are being observed in field condition, which warrants precise identification of the pathogen to adopt various management strategies. Similarly, appearance of watery lesions on pseudostem as well as blackening and breaking of pseudostem is becoming rampant in field conditions. In this context, diseased plant samples showing leaf and pseudostem rots were collected from Thiruvananthapuram, Kollam, Pathanamthitta and Kottayam districts of Kerala and isolated the organisms found attached with the samples. The organisms were isolated and purified. Pathogenicity of the isolated organisms were tested under *in vitro* conditions using detached leaves and was proved as species of *Phytopthothora, Fusarium* and *Colletotrichum.* An ad-hoc recommendation is formulated to combat the pathogens.

BO 03. Cassava root and stem rot, an emerging menace to cassava growers of Kerala

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Root and stem rot diseases constitute major constraint for most of the horticultural crops. In 2019, unlike tuber rot caused by *Phytophthora palmivora* reported earlier which lacks foliage symptoms, root rot causing wilting in cassava fields were noticed in wet lands of Kerala and survey revealed 40 to 100% loss. In this light, importance of the study was realized with the aim of characterizing the root rot disease and identifying their associated causal agents. The symptoms started at all stages of crop growth, immediately after planting till harvest. After planting the stem dried due to root rot before the plant develops. After the development of plant, the disease cause rotting in the collar region of the stem and the roots. It was observed that the rotting was initiated in roots and further spread to the tubers. The plants showed initially yellowing and drooping of lower leaves followed by drying. In severe cases the plant wilted and the entire tubers rottened. Since the disease advances after rain it was understood that moisture played an important role. Cassava stems and roots with root rot symptoms were sampled from different districts, viz., Kollam, Kottayam and Thiruvananthapuram and the associated pathogens were isolated. Morpho cultural and molecular tools identification showed the association of *Fusarium solani* in all the samples. The pathogenicity was tested on detached roots and tubers *in vitro*. Preliminary studies showed inhibition of the pathogen by *Trichoderma asperellum* (CTCRI-Tr9) and Carbendazim. Adhoc recommendations have been given to the farmers for managing the disease based on earlier practices for root rot pathogens, discussion with multidisciplinary scientists, extension personnels and farmers' information on disease

development. Studies on predisposing factors and development of specific management strategies are the need of the hour.

BO 04. First report of *Fusarium falciforme* (FSSC 3 + 4) causing root decay of arecanut, *Areca catechu* L.

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During 2018 summer season, several young arecanut seedlings exhibited yellowing, drying, drooping and wilting symptoms in farmer's fields located in Dakshina Kannada district of Karnataka, India. Longitudinal section of the infected seedlings showed extensive decaying of fibrous roots which extended up to collar region and ultimately resulted in death of young seedlings. A series of cultural, morphological, molecular characterization using multi-gene phylogeny, and pathogenicity assays with Koch's postulates confirmed the association of *Fusarium falciforme* (FSSC 3 + 4) as the causal organism of arecanut root decay disease. To the best of our knowledge, the present study confirms the first report of root decay disease caused by *F. falciforme* in arecanut.

BO 05. Re-emergence of *Exserohilum rostratum* causing black spot of coconut

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During late 2020, tiny black spots were noticed (initially restricted to petiole part and later seen on leaves as well as young nuts) in tall palms in Andaman plot of coconut farm maintained at CPCRI Research Centre Kidu. The tiny black spots later coalesce to form dark lesions with grey center leading to drying of the entire infected coconut leaf. A series of cultural, morphological, molecular characterization using multi-gene phylogeny, and pathogenicity assays with Koch's postulates confirmed the association of *Exserohilum rostratum* as the causal organism of black spot disease.

E. rostratum is known to be one among causal agents responsible for leaf rot disease of coconut especially in Root (wilt) affected areas. To the best of our knowledge, the present study confirms the first report of black spot disease of coconut by *E. rostratum* as well as the re-emergence of the pathogen in Root (wilt) free areas.

BO 06. First record of a novel begomovirus and satellites associated with leaf curl disease of passion fruit from India

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Passion fruit is one of the important fruit crop grown in parts of South and North Eastern states of India. Leaf curl symptoms typical to begomovirus infection were observed on passion fruit plants was collected from Madikeri District, Karnataka State, India. The disease incidence was ranged from 10-20 per cent. In order to find out the begomovirus associated with leaf curl disease of passion fruit, twenty infected samples collected from the different locations were subjected to PCR analysis using primers specific to begomovirus. The complete DNA-A sequence of passion fruit infecting begomovirus with other begomoviruses revealed that it shared nucleotide (nt) identity of 87.8 to 88.8 per cent with *Ageratum enation virus.* This indicated the association of novel begomovirus with leaf curl disease of passion fruit in India, for which we propose the name, *Passion fruit leaf curl virus* (PFLCuV). PFLCuV associated betasatellite shared 98.3 per cent sequence identity with *Tomato leaf curl Bangladesh betasatellite*, while alphasatellite had 95.7 per cent sequence identity with *Cotton leaf curl Multan alphasatellite*. Recombinant analysis indicated major component of PFLCuV DNA-A might originated from recombination of earlier reported begomoviruses. Recombination as well as GC plot analysis showed that the recombination occurred in the genome regions having low GC content regions of PFLCuV. However, there is no evidence of recombination in alphasatellite and betasatellite associated with leaf curl disease of passion fruit.

BP 01. Occurrence of leaf blight by *Rhizoctonia solani* in black pepper nursery

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Incidence of leaf blight by *Rhizoctonia solani* was observed in Pepper Research Station, Panniyur, Kannur under Kerala Agricultural University during June 2021. This was the first incidence of *Rhizoctonia* in Black pepper nursery in Pepper Research Station as per the previous records. Prolonged heavy rainfall and high relative humidity might have triggered the leaf blight incidence. The observations from the observatory in PRS, Panniyur in the month of June 2021

showed as 534.4mm rainfall with 21 rainy days and 94 % relative humidity. Disease symptoms were observed initially as grey spots on pepper leaves. Spots which are irregular in shape, later join together to form leaf blight with dark brown border. Disease incidence recorded was 3.5 to 5 per cent. Finally blighting of the whole leaf occurred and disease was found to attack on stem of the cuttings causing death of seedlings. Infected leaves were found to be attached together which is a characteristic symptom of Rhizoctonia attack. The isolated fungal pathogen was identified as *Rhizoctonia solani* by cultural and morphological characters. Fungicides like Copper Oxy Chloride (3%), Hexaconazole (2%), and Carbendazim (1%) along with control was evaluated against the pathogen under *in vitro* conditions. The obtained results showed complete growth inhibition for Hexaconazole 2 per cent and Carbendazim 1 per cent concentration. Both the above fungicides were equally effective in controlling the disease under *in vivo* conditions with 99% recovery compared to control.

BP 02. Occurrence and detection of *Tomato leaf curl New Delhi virus* isolate causing yellow mosaic disease in vegetable gourds of Karnataka

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Ridge gourd (*Luffa acutangula* L.) , bitter gourd (*Momordica charantia* L.), Ivy gourd (*Coccinia grandis* L.) and Bottle gourd (*Lagenaria siceraria* L.) plant samples showing severe mosaic symptoms were collected from Chikmagalur, Davanagere and Shivamogga districts of Karnataka. Begomovirus infection was confirmed by PCR using begomovirus specific primers like DangA/DangB and PAL1v/ PAR1c. Amplified PCR products (560 bp and 1.2 to 1.3 kb) were sequenced and characterized. Based on sequence analysis, begomovirus associated with all the four gourds of Davanagere samples were found to be a member of a bipartite begomovirus species, which were closely related to tomato leaf curl New Delhi virus (ToLCNDV). Whereas, ridge gourd and bitter gourd samples of Chikmagalur infected by begomovirus were found to be a member of a begomovirus species, which are closely related to Tomato leaf curl Joydebpur virus and Tomato leaf curl Bangladesh virus, respectively. ToLCNDV infecting all four gourds were sequenced and they found to share 96 to 100% (nt) identity with the DNA-A-like sequence of ToLCNDV isolated from cucurbits, tomato and chilli, respectively. The Phylogenetic tree was constructed for MZ664277 (ridge gourd), MZ664278 (bitter gourd), MZ664279 (ivy gourd) and MZ664281 (bottle gourd) isolates (amplified by PAL1v/PAR1c primer) and ToLCNDV of ridge gourd, bitter gourd and ivy gourd was closely related and formed a single cluster except bottle gourd that formed a separate cluster. Whereas, bottle gourd form a separate cluster. The present study has identified ToLCNDV as the cause of YMD of all the four gourds.

BP 03. Association of a novel virus belonging to the family *Totiviridae* with plant pathogenic *Colletotrichum gloeosporioides* isolated from cardamom

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Mycovirus are viruses that infect fungi. Mycoviruses that cause hypovirulence of the fungi have potential as biocontrol agents. *Colletotrichum* spp. is an important pathogen associated with diseases of many crops including spices. So far 20 mycoviruses have been reported from *Colletotrichum* worldwide. However, there is no report of mycoviruses from India. Hence the present study was initiated to look for the association of viruses with *Colletotrichum* spp. A total of 18 *Colletotrichum* spp. were isolated from black pepper and cardamom. Five-day old liquid cultures of fungi were used for dsRNA isolation. DNase1 and S1 nuclease treated dsRNA was analysed on agarose gel. Out of the 18 samples, only the *Colletotrichum gloeosporioides* from cardamom showed dsRNA presence indicating association of a mycovirus. The dsRNA was purified and used for double stranded cDNA synthesis. PCR amplified products were cloned and sequenced. Among 12 clones, one clone showed mycovirus like sequences that contained 843 nucleotides potentially coding for 281 aminoacids. This region contained partialcoat protein (1-362) and RNA-dependent RNA polymerase (RdRp) (363-843) genes that showed identities with members of *Totiviridae*. Further, analysis using amino acid sequence of RdRpwith corresponding region from the genera, *Victorivirus and Totivirus*s howed an identity ranging from 22–29% and 10–18% respectively. Thus, as per ICTV guidelines, the present virus is a novel member of the *Totiviridae*. Exact taxonomic identity of the virus isolate will be known only after obtaining complete sequence of the RdRp gene. This is the first report of a mycovirus infecting *Colletotrichum* from India.

BP 04. First report of natural infection of tomato by *Potato spindle tuber viroid* (PSTVd) in India

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Potato Spindle Tuber Viroid (PSTVd) is a non-coding infectious circular small RNA molecule known to cause diseases in different agricultural and horticultural crops. In the present study, a field study was carried out in Southern Karnataka to assess the pospiviroid infections of tomato plants. Plants showing disease symptoms such as severe leaf curling, epinasty, chlorosis, purpling and stunted growths that are characteristics of viroid infection were collected along with

asymptomatic plants and subjected to viroid detection by conventional RT-PCR using universal (Pospi1-RE/Pospi1-FW) and a specific set of primers (3H1/2H1). A sample collected from the Mandya district showed an amplicon size of ~361bp and confirmed PSTVd infection. The amplicons were cloned into pGEM®-T Easy vector, sequenced, and the respective resultant sequences were deposited to NCBI GenBank with an Accession No. MW114500 and MW114501. Further, the sequence alignment and phylogenetic analysis between the isolated PSTVd of tomato and that of the other isolates of PSTVd clustering in a single clade, authenticating the close phylogenetic relationship among strains indicating the regional association of PSTVd. The bioassay conducted on tomato plants showed typical PSTVd like symptoms after four weeks of post-inoculation. The viroid infection was re-confirmed through RT-PCR. To the best of our knowledge, this is the first report of natural infection of PSTVd in tomato crop in India.

BP 05. *Neofusicoccum parvum* causing dieback disease of *Melia azedarach* in Karnataka state (India)

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Melia azedarach L. (Meliaceae) is a multipurpose wild tree species native to India and has been naturalized around human habitats in sub-tropical countries. Being an ornamental tree it also has medicinal and pesticidal properties. Studies have revealed that extracts of fruits, seeds and leaves of *Melia azedarach* have medicinal and pesticidal activities against several pathogenic and pest organisms. In 2019 dieback disease was noticed on 33 out of 44 trees observed in Mysore and Tumkur region of Karnataka state (India). The disease symptoms include the gradual wilting and drying of young shoots from top to downward. The affected tree branches were visible as dry, defoliated and remain attached to the main tree trunk. The fruits were blackish and shrivelled giving a burnt appearance. The disease incidence was 75%. The pathogen was isolated on PDA medium and cultural characters were studied on different media like Sabouraud Glucose Agar, Czapek Dox Agar, Yeast Extract Agar, Potato Dextrose Agar and Oatmeal Agar. The genomic DNA was isolated by CTAB method and the rDNA region was amplified by PCR and sequenced using universal primers ITS1 and ITS4. The pathogen was identified as *Neofusicoccum parvum* (Pennycook & Samuels) based on the morpho-cultural, sequence data and phylogenetic analysis. The Koch's postulate has been proven by detached stem assay where inoculated twigs showed typical symptoms of dieback with wilting and drying of terminal shoots. The disease is responsible for poor growth of medicinally important tree species in the region hence there is an urgent need to manage the dieback disease using integrated management practices.

BP 06. First report of *Parthenium hysterophorus* susceptibility to *Meloidogyne hapla* in Nilgiris, Tamil Nadu

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The Nilgiris is the only horticulture district among the 38 districts of Tamil Nadu state, located at an altitude of 900-2636 MSL with sloppy landscape. Little millet (*Panicum sumatrense*), finger millet (*Eleusine coracana*) and wheat (*Triticum dicoccum*) were the traditional cereal crops of this land, yet shrank to small pockets due to spread and preference of alternate high remunerative vegetables, fruits, flowers and medicinal plants. These newly introduced crops demand heavy fertilizer and manure inputs especially the farm yard manure (FYM). The FYM not only helps to neutralize the acidic soil pH of the Nilgiris but also to loosen the soil to facilitate the crops with below ground economic part like carrot, potato, garlic, beetroot, radish and turnip. However, the district's cattle population is not sufficient enough to meet the demand for FYM. Hence, the Nilgiri farmers are bringing the FYM from the low altitude plains area such as Pollachi. Due to lack of awareness, along with the FYM many weed species such as *Trianthema portulacastrum*, *Chenopodium album*, sedges and *Parthenium hysterophorus* spread from plains to this high altitude area. Among them the parthenium is found to be recent and is spreading in a very fast manner even in altitudes higher than 1800 MSL. Due to higher susceptibility of horticulture crops to root-knot nematode (RKN), *Meloidogyne* spp., and the polyphagous nature of this nematode paved the way for routine survey to identify the susceptible crop and weed hosts. During one such survey we came across RKN infested galled roots of parthenium. Due to the economic importance of RKN-parthenium association, a systemic survey was conducted and the incidence of RKN infestation was found to be more than 50%. The nematodes were teased out from the roots and were identified as *Meloidogyne hapla* and *M. incognita* through perineal pattern studies. Visual observation of galled roots under the microscope showed the presence of healthy egg masses and juveniles of RKN. Hence for the first time, we are reporting the ability of *Meloidogyne hapla* to infest, establish and reproduce on *Parthenium hysterophorus*. We further reiterate the necessity of continuous surveillance to prevent the accidental introduction of new pest and disease to Nilgiris as it is a hub for plant introduction in India since British period. Moreover, there is a need for designing a novel and sustainable nematode management strategies to minimize the establishment of RKN *via* weed hosts.

BP 07. Isolation, characterization and bio-management of *Villosiclava virens*, a unique flower-infecting fungus causing rice false smut disease in India

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Villosiclava virens (*Ustilaginoidea virens*) an ascomycete fungal pathogen that causing false smut disease in rice and has become a serious production constraint in various rice-growing regions of India due to its detrimental effects on grain yield and quality. A roving survey was conducted during *Rabi* 2020 in Tamil Nadu, Uttar Pradesh and Karnataka state and the false smut disease severity was ranged between 9.2– 27.9 %. During survey heavy incidence was noticed in a variety BPT 5204. Totally 97 fungi were isolated and characterized from rice smut balls. Among them nine Uttar Pradesh, thirteen Tamil Nadu and two Karnataka isolates were identified as *V. virens* and remaining were as associated seed pathogens *viz.*, *Microdochium* sp., *Fusarium* sp., *Curvularia* sp., *Nigrospora* sp., *Aspergillus* sp., *Penicillium* sp., *Trichoderma* sp., *Epicocum* sp. and *Trichothecium* sp. based on cultural and spore morphology. The identity of the pathogen was further confirmed through PCR analysis using ITS 1 and 4 primers and sequencing (NCBI) and the identified cultures were deposited at internationally recognised culture collection NAIMCC, Mau. Different isolates of *V. virens* showed variation in the cultural morphology, size, colour and shape of the conidia. A total of 16 *Trichoderma*, 10 *Bacillus*, 8 *Pseudomonas* strains were screened against *V. virens* among them, *T. longibrachiatum, T. afroharzianum, T. harzianum, Bacillus subtillis, P. fluorescens* and *P. aeruginosa* were showed highest percent inhibition. Further these strains were evaluated under pot condition along with combination of *T. harzianum + B. subtillis + P. fluorescens* (Biogrow) in three set of experiments through seed priming, soil application and foliar application. Rather than soil application seed priming and foliar application find more effective to control disease. The survivability of *V. virens* in the soil was also studied by applying giant cultures produced on rice seeds and grains. The complete experiments were conducted in ICAR-NBAIM, Mau with a time period of study.

BP 08. *Alternaria* leaf spot: An emerging threat to oat cultivation

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Oat (*Avena sativa* L.) is an important cereal grain mainly grown for its seed for human consumption as oatmeal and as livestock feed. Oat is the rich source of globulin or legume like protein, avenalin, which is major storage protein. Oat protein is nearly equivalent in quality

to soy protein, which World Health Organization research has shown to be equal to meat, milk, and egg protein. Leaf spot is an emerging malady in cultivation of oat. The disease incidence on plants was ranged between 43 to 57 percent. Symptoms appeared on leaves as small dark-brown spots surrounded by a yellow halo later turned to irregular necrotic spots with a yellow halo. The leaf spot pathogen was identified as *Alternaria* spp. based on morpho-cultural characteristics. Further confirmation at molecular level was carried with PCR assay by using some gene or gene regions *viz.,*internal transcribed spacer (ITS), small subunit (SSU), RNA polymerase second largest subunit (*rpb2*), glyceraldehyde-3-phosphate dehydrogenase (*gapdh*), Alternaria major allergen (*Alt a1*), endopolygalacturonase (*endoPG*), an anonymous gene region OPA10-2, KOG1058 and translation elongation factor 1-alpha (*tef1*) were PCR amplified and the resultant products were sequenced and deposited in NCBI GenBank. Never the less more attention is needed to overcome the threat to oat cultivation by employing good management practices and finally for increasing productivity.

BP 09. Dry root rot of pigeonpea: An increasing threat to pulse production due to climate change

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Pulses are the source of vegetarian protein and their demand is increasing many folds than production and supply. Major hurdles in pigeon pea were Fusarium wilt and much of the efforts during the past three decades were concentrated on identifying and release of resistant cultivars and formulation of integrated disease management practices. The monitoring of pigeon pea diseases grabbed the attention towards minor diseases becoming major. This shift is a result of climate change and its induced implications. Like *Fusarium*, another soil borne pathogen *Rhizoctonia bataticola* (Taub.) Butler infecting pigeon pea has been found stretching its pathogenicity annually by increased disease incidence across many pigeon pea growing districts in North Karnataka. Changing rainfall pattern especially quantity, distribution and related weather parameters are much favoring the disease development. The highest disease incidence was 26 per cent during 2015 and has reached to 51 to 67 and 75 to 83 per cent in severely infected plots at Kalaburagi district popularly known as pulse bowl of Karnataka during 2020 and 2021. The incessant heavy rains with decreasing rainy days followed by recurrent and prolonged dry spells for a period of 15 to 25 days were found predisposing the crop for infection by the pathogen. Infection was found both on stem and roots leading to destruction of vascular bundles as a result death of the affected plants was noticed in severely affected plants. Cent percent yield losses were recorded in plants wilted before or at the time of flowering where drastic yield losses were noticed at post flowering. Irrespective of cultivars grown severe infection was evident across the district and in neighbouring districts also. There is a need to

consider impacts of climate change and its influence on pathogens dynamics and infections in their cultivated host crop species for developing suitable management strategies.

TECHNICAL SESSION 3
ADVANCES IN PLANT DISEASE DIAGNOSTICS

Chairperson	:	Dr. Malathi, V.G., Rtd., Principal Scientist, ICAR-IARI
Co-chair	:	Dr. Ishwara Bhat, A., Principal Scientist, ICAR-IISR
Convener	:	Dr. Veena S.S., Principal Scientist, ICAR-CTC
Rapporteurs	:	Dr. Chaitra, M. and Dr. Thava Prakasa Pandian, Scientist, ICAR-CPCRI

LL 03. Present status on molecular diagnosis, characterization, and management of citrus greening disease (Huanglongbing) in India

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Citrus is the third most important fruit crop in India and plays an important role in the national economy. India ranks third, after China and Brazil, in terms of total production. Although there are several fold increase in area under citrus cultivation, and total production in last five decades, incidentally, national productivity *i.e.* yield/ha remains almost static as compared to developed countries. One of the major reasons behind this poor situation is the infection by several systemic, graft transmissible, virus and virus-like pathogens that affect citrus plant health, productivity, fruit quality, and finally cause citrus decline. Nearly 60% of total infections are attributed because of infection by all such systematic pathogens against which there is virtually no chemical control is available.

Citrus greening disease (HLB) caused by '*Candidatus* Liberibacter asiaticus (*C*Las)', a Gram negative alpha Proteobacterium is considered as the most important disease and principal cause of citrus decline in India. Extensive surveys revealed its presence in major citrus growing states like Maharashtra, Punjab, Andhra Pradesh, North-Eastern states etc. Among commercially important citrus cultivars, incidence of greening was more on sweet orange and mandarin varieties compared to other cultivars like acid lime and lemon. There have been tremendous improvements in pathogen detection by sophisticated molecular diagnostic tools like PCR, Real Time PCR, RPA-LFA etc. that certainly have many advantages in terms of sensitivity, robustness and speed. Different sets of greening bacterium-specific primers were designed, synthesized and used for amplification of 16S rDNA, 16S/23S intergenic regions, ribosomal protein genes and *omp* genes. Duplex-PCR, real time PCR, LAMP and RPA based diagnostic tools have been standardized to detect the pathogen in both plant and citrus psyllid. Recently, LAMP-based rapid diagnostic kit for Citrus greening has been developed. Most importantly, developed RPA-LFA-based rapid diagnostic kits for Citrus greening which is rapid, highly sensitive, and could be performed even in small laboratories located in remote places with limited resources. Genetic variability studies based on the tandem repeats at hyper variable genomic locus CLIBASIA_ 01645 reveals that the Indian populations of '*Ca*. L. asiaticus' is more diverse than other reported populations. Standardized molecular diagnostic tools have been used to successfully implement citrus bud wood certification program at the institute for production of disease-free planting material of citrus.

Until today, the effectiveness of variety of broad-spectrum antibiotics *viz.* Oxytetracycline, Penicillin, Streptomycin, Carbenicillin, Cefalexin, Rifampicin, Sulfadimethoxine etc were reported on HLB infected trees under green-house or field conditions. In 2016, Oxytetracycline and Streptomycin received emergency approval for use

in citrus groves of Florida, USA for foliar use by USEPA. However, the effectiveness of these treatments for surpassing HLB applied foliar is still an on-going debate as foliar application of antibiotics have very limited uptake, therefore, not reaching target sites where the *C*Las reside. The antimicrobial chemical compound needs a delivery system to reach at the targeted site (phloem). Therefore, a method for systemic delivery of cargos in vascular plants and evaluated efficacy of antimicrobial Nano-Zinc Oxide-25 albumin protein formulation against *C*Las in planta has been standardized. Further studies have also been made on antioxidant defense system of *C*Las which is helpful in developing antimicrobials against citrus greening disease. Characterization of numerous critical proteins of *C*Las including a Bacterioferritin comigratory protein family 1-Cys peroxiredoxin (CLa-BCP), Periplasmic solute binding protein (CLas-ZnuA+), Cystine binding protein (CLasTcyA) etc. reveals possible target site of various anti-microbials. However, more research and evaluation is needed before large scale recommendation of using any novel approaches for HLB management.

IL 05. On-site real-time detection of plant viruses

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Of-late on-site detection of plant viruses are gaining importance in agriculture. Timely eradication of virus infected trees or plants is the primary step in the management of obligate pathogens like viruses pathogens. In order to identify the viruses in the perennial plants or trees, sensitive and rapid real time detection kits are needed. Lateral flow immune assays which is very common in the medical field is also becoming popular in ensuring disease free planting material in Horticulture. Fruit trees like citrus, apple, plums, papaya, banana (herbaceous) and grapes (vine) and other vegetatively propagated spices, tuber, ornamental crops are harbouring dozens of viruses which can act as inoculum for further spread through vectors as well as primary transmission by the cuttings, seedlings, grafts etc., Hence for monitoring the viral diseases in the field, regular surveillance of the orchards is a must activity and while performing the disease monitoring, on-site detection tools will assist to find out the presence of pathogens in the field on real time. Immuno-based lateral flow strip kits are available both commercially and from research laboratories. The basic principal of this technique is functionalizing the gold nanoparticles using specific immune gamma globulins produced against the pathogen of interest and apply them in the real time for in-field detection. For pathogens which are less immunogenic this immune based kit may not be suitable and alternatively detection by targeting their genome is possible and nucleic acid lateral flow assay kits are widely adopted for the detection of many viral pathogens. For NA based lateral flow strips either loop-mediated isothermal amplification (LAMP) or recombinase polymerase amplification (RPA) for amplifying the target is a pre-request and fluorophore-based probes are also applied in the detection. The onsite detection tools

can be used by farmers, plant pathologists, tissue culture industries and quarantine departments for monitoring the virus during surveys, import and exports, and surveillance and germplasm curators can also use to monitor the virus in germplasm materials. In this talk the recent developments in the on-site or point-of-care detection of plant viruses are discussed in detail.

IL 07. *Fusarium sacchari,* an enigmatic pathogen infects sugarcane with complex epidemiology

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Sugarcane crop experiences production losses from different diseases in the country, however, the diseases wilt and pokkahboeng (PB) caused by the same fungal pathogen *Fusarium sacchari* are unpredictable leading to huge losses in different states. Further, epidemiology of these diseases and inter-relation among the two *Fusarium* diseases have not been addressed so far. We have conducted detailed studies on epidemiology of these diseases and on the identity of associated pathogen. Wilt, a systemic disease causing death of sprouted young shoots and stalks in sugarcane. Characteristic pith cavities in the internodes along with tissue discolouration of varying shades are the typical wilt symptoms in sugarcane. Ultimately, the affected plants exhibit yellowing and drooping of leaves in the canopy, de-topping of the spindle, paleness of the rind etc. In young canes, either entire shoots show drying or the dead canes show de-topped phenotype. During later growth crop phases, the disease severity increases with drying of canes in large patches in the field. PB exhibits different phenotypic symptoms on foliar tissues that vary from chlorotic patches on the leaves, reddish stripes on the veins, distortions in leaf growth to deformed lamina. In severe cases, the fungus enters inside the stalks causing top rot symptoms and this PB phase leads to death of meristem, bud sprouting and systemic wilt development in the stalks from top. Occasionally, the pathogen causes a peculiar 'knife-cut' symptoms on the stalks and shortening of internodes. We could record the varying phenotypic symptoms of these two diseases in sugarcane and clearly established cause of these diseases by the same fungal pathogen. Prevailing soil and weather factors, inoculum density and varietal resistance were found to influence these diseases development in sugarcane.

IL 09. Nano-technological approaches for diagnosis and management of plant diseases

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Nanotechnology is an emerging as the sixth revolutionary technology in the current era after the Industrial, Nuclear Energy, Green, Information Technology and Biotechnology

Revolutions. It is being used in wide range of subjects such as physics, chemistry, biology, material science, electronics, medicine, energy, environment, health, agriculture and allied sectors with varied applications. Nanotechnology deals with manufacturing, study and manipulation of matter at nano-scale in the size range of 1-100 nm which are called as nanoparticles (NPs). Nano-phytopathology is a cutting-edge science which uses nanotechnology for detecting, diagnosing and managing plant diseases and their pathogens at an early stage by avoiding epidemics of diseases. Plant pathologists are striving to develop a successful solution for protecting fruits, plantations and agricultural crops from pathogens like bacteria, fungi, viruses and nematodes. In the synthesis of NPs usually physical and chemical methods are used. In addition to this, green nanotechnology involving plant or microorganisms or their products/extracts are equally effective to maintain stability and to reduce the side effects. The integration of the principles of green chemistry to nanotechnology towards synthesis of green NPS is a current requirement in plant pathology. Employing plants and microbial metabolites towards synthesis of NPs are emerging as advantageous due to the presence of anti-oxident bio-molecules. The methods for designing of nanoparticles generally involve top-down or bottom-up approach. Nano particles are characterised by UV–visible spectrophotometry, Dynamic Light Scattering, Scanning Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy and energy-dispersive X-ray analysis and Fourier transform infrared spectroscopy. Elemental sulphur and copperare non-systemic and repeated applications are usually required to give good protection. Here is a wide scope and benefits are there if sulphur and copper acts systemically if converted them in to nanoscale, which may help in prolonged and broad fungicidal action.

Literature reveals that Infectious chlorosis of banana (*Cucumber mosaic virus*) was diagnosed by gold nanorods of pinkish red colour with size of 15 to 55 nm. Healthy sample remained pinkish red while diseased showed change from pinkish red to black which was confirmed by immunological studies. Gold NPs based optical immunosensors are used for detection of karnal bunt of wheat.Nano-formulations of fungicides which reduce the size of active ingredient to nanoscale and also by nano encapsulating them have been developed by Syngenta viz., Banner MAXX fungicide (ai. propiconazole) and Apron MAXX (ai. fludioxonil). Nano formulations may be made to release slowly / quickly, or release depending on factors like moisture, heat and pH of the medium.metalloid and metaloxide NPs on Fusarium wilt of watermelon was found effective. Similarly silver-neem nano particles were tested for postharvest anthracnose disease management in banana by spraying and it was found effective at 0.1 and 0.2 % concentration. Antimicrobial nano-zinc oxide-2S albumin protein formulation significantly inhibited the growth of *Candidatus Liberibacter asiaticus* in planta by aqueous formulations by trunk-injection of 2S albumin (330 ppm) coupled with the Nano-ZnO (330 ppm) at 1:1 ratio.Nanomaterials have been integrated into disease management strategies and diagnostics and as molecular tools.

CO 01. Colorimetric closed tube Loop Mediated Isothermal Amplification (LAMP) assay for the detection of *Banana bunchy top virus* in banana (*Musa* spp.)

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Banana bunchy top disease caused by *Banana bunchy top virus* (BBTV) is a major ailment of banana resulting in complete yield loss. A sensitive and rapid diagnostic method is necessary for efficient management of this disease. The common molecular detection method used for BBTV is PCR which requires instrument for thermal cycling and post amplification sample handling which often predisposes to sample cross contamination. In the present study, a colorimetric closed tube Loop mediated isothermal amplification (LAMP) assay was developed for rapid and sensitive detection of BBTV. Six LAMP primers were designed targeting BBTV coat protein gene. The final reaction mixture contained 50 ng template DNA, 1.4 mM each dNTP, 0.8 µM each primer FIP and BIP, 0.2 µM each primer F3 and B3, 0.4 µM each primer LF and LB, 0.8 M betaine, 4 mM MgSO, 1x Thermopol buffer with 2 mM MgSO4, 8U Bst polymerase large fragment and 120 µM HNB dye in 25 µl reaction volume. Isothermal amplification was set at 65oC and end point detection made using Hydroxy Naphthol Blue (HNB) dye where the positive samples showed colour change from violet to sky blue. Molecular characterisation of LAMP amplicon was made with restriction analysis and sequencing. Sequence analysis confirmed that amplification corresponded to BBTV coat protein gene. Comparison of LAMP assay with conventional PCR showed that LAMP is more rapid and sensitive than PCR and hence LAMP assay developed here has potential application in virus indexing.

CO 02. One step Reverse Transcription Loop Mediated Isothermal Amplification (RT-LAMP) for diagnosis of *Banana bract mosaic virus* in banana (*Musa* spp.)

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Banana bract mosaic virus (BBrMV) is one of the most important viruses affecting banana and plantain. Available molecular detection technique like the Reverse Transcriptase Polymerase Chain Reaction needs post amplification sample handling step predisposing to sample cross contamination. A one-step Reverse Transcriptase Loop Mediated Isothermal Amplification (RT-LAMP) assay coupled with colorimetric detection was developed for easy and quick detection of BBrMV in banana. The viral coat protein gene was amplified under

isothermal conditions at 65 ºC. The final optimised RT-LAMP reaction contained 2 µg RNA, 1.4 mM each dNTP, 0.2 µM each primers F3 and B3, 0.8 µM each primers FIP and BIP and 0.4 µM each primers LF and LB, 1 M betaine, 4 mM $MgSO_4$, 1x Thermopol buffer with 2 mM $MgSO_4$, 8 U Bst polymerase large fragment, 1 U M-MLV reverse transcriptase and 2.5 U RNasin® plus RNase inhibitor in 25 µL reaction volume.The positive samples showed a colour change from violet to sky blue in the presence of 120 µM of Hydroxy Naphthol Blue (HNB) dye in the reaction mixture. Molecular characterisation of RT-LAMP amplicons was done using restriction profiling and sequencing. The RT-LAMP assay was validated using field collected banana samples. The assay successfully detected the virus from symptomatic banana samples while the healthy samples showed no amplification. Samples from banana plants showing symptoms of other viruses like *Banana bunchy top virus*, *Banana streak virus* and *Cucumber mosaic virus* were also tested and these samples showed no amplification.

CO 03. Evaluation of PCR markers for mating type determination in *Phytophthora* spp. infecting black pepper

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The members of *Phytophthora* species are either heterothallic which invariably requires two mating types i.e. A1 and A2 to produce oospores or homothallic which can produce oospores in a single culture. Mating type is an important strain characteristic influencing population structure of the pathogens. Hybridization between opposite mating type increases genetic variability and promotes survival of the pathogens. Moreover, sexual reproduction may spread the trait of fungicide resistance through genetic recombination and therefore it is imperative to monitor the occurrence of mating types in a pathogen population. In the present study, the PCR markers *viz*., PCAP1 and PCAP2 primers were used to determine mating types in *P. capsici* and *P. tropicalis* infecting black pepper. A total of 150 isolates representing *P. capsici* (68) and *P. tropicalis* (82) were tested and found 508 bp amplicon in all the *P. capsici* isolates. As per earlier report, amplification of 508 bp indicates A2 mating type while A1 mating type produces 997 bp amplicon. Subsequently, the 508 bp amplicon was sequenced and blast analysis showed 99.1 % similarity with the reference A2 isolate (TL1) sequence. In contrast, the *P. tropicalis* isolates did not yield any band indicating that these primers cannot be used for *P. tropicalis*. Hence, it is concluded that, the *P. capsici* isolates from black pepper probably belongs to A2 mating type which needs to be confirmed further through mating studies with reference A1 and A2 mating types. In addition, these primers can also be used to differentiate the *P. capsici* and *P. tropicalis* isolates of black pepper.

CO 04. Molecular diagnostics of emerging diseases of vegetables in Kerala

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Molecular characterization of candidate genes, besides morphology aid in accurate identification of plant pathogens. Studies using candidate genes and concatenated phylogenetic analyses resulted in accurate identification. An emerging disease of yardlong bean (15-30 % incidence), basal stem rot and blight caused by *Sclerotium rolfsii* was identified by sequence characterization of fungal *ITS* region, amplified using ITS4/ITS5 primers. BLASTn revealed 99.69 % similarity with *S. rolfsii*. The disease was first of its kind in Kerala and India.

Another emerging disease of yardlong bean was leaf blight caused (40-60 % incidence). The *ITS* region, *EF1-α* and *TUB* were sequence characterized. BLASTn analysis of *ITS* revealed 100 % identity with *Diaporthe* sp. and EF1-α showed 99.72 % identity with *D. tectonae*. Phylogenetic analysis with concatenated sequences of *EF1-α* and *TUB* genes confirmed the fungus as *Diaporthe tectonae,* its first report in India and world.

Leaf spot is an emerging disease of *Basella rubra* (50-85 % incidence). Analysis of *TUB-2* and *ACT* genes and *Mat-Apn1* loci revealed 100 % identity with *Colletotrichum siamense*. Concatenated phylogenetic analysis using *ACT, TUB2* and *Mat-Apn1* sequences confirmed it as *C. siamense*.

Symptoms of suspected phytoplasma infection were observed in cauliflower (10 % incidence). Sequencing of amplicons of 16S *rRNA* and *SecA* genes revealed 99.77 % identity with *Candidatus* Phytoplasma cynodontis which is its first instance in India and worldwide. Emergence of new diseases is a great challenge and constant vigil is required on timely identification and management. In depth studies are required towards management of these new diseases.

TECHNICAL SESSION 4
A RECENT ADVANCES IN DIAGNOSTICS AND MANAGEMENT OF PHYTOPLASMAL DISEASES

Chairman	:	Dr. Krishna Reddy, M., Principal Scientist & Head , ICAR-IIHR
Convener	:	Dr. Merin Babu, Scientist, ICAR-CPCRI
Rapporteurs	:	Dr. Prathibha, V. H. and Dr. Thava Prakash Pandian, Scientist, ICAR-CPCRI

LL 04. Diagnosis, diversity, transmission and management of phytoplasma diseases in India

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Phytoplasmas have been reported on diverse plant species in India including cereals vegetables, fruits, ornamentals, palms, sugarcane, oil crops, cotton, medicinal plants, trees, weeds etc. In last decade, about more than 100 new plant species were identified as natural hosts of different phytoplasma groups in India belonging to eleven phytoplasma groups. Brinjal little leaf, tomato big bud, sesame phyllody, sugarcane grassy shoot and white leaf, coconut root wilt, areca nut leaf yellows, sandal spike and many ornamental melodies and malformations are the most prevalent phytoplasma diseases causing serious economic losses every year. Some very unique symptoms, like phyllody, witches' broom, shoot proliferation, malformations, little leaf and yellows are the primary identity features for the diagnosis of the phytoplasmas in fields. But, mainly PCR based molecular assays employing 16S rRNA, 16Sr- 23S rRNA spacer region and several multilocus genes specific primers, RFLP analysis and complete genome sequencing the authentic and reliable diagnosis techniques forthe taxonomic classification of phytoplasma strains. Phytoplasma are vegetatively transmitted through grafting, tubers, plant cuttings and cuscuta. Different leafhopper and plant hopper species are reported to transmit phytoplasma strains in India. The suggested effective management practices in India are roguing, pruning, resistant varieties, heat therapy, use of tertracycline, apical meristem culture, control of insect vectors and other natural host reservoirs. Currently the major focus of phytoplasma research in India is pathogen identification, diversity, epidemiology, integrated pest management and complete genome sequencing.

IL 10. Genotaxonomy of SCGS phytoplasma achieved through Targeted Hybrid Metagenomic Assemblies of plant microbiomes: *'Candidatus* Phytoplasma sacchari' a case study

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The Rice Yellow Draft (RYD) or 16SrXI-B group phytoplasmas are known to be associated with Sugarcane grassy shoot (SCGS), Coconut Root Wilt (CRWD), Wheat Yellow Stunting (WYS) and Arecanut Yellow leaf (AYL) diseases. Being placed distinctly away from both the phylogenetically related species '*Ca. Phytoplasma cynodontis'* and '*Ca. P. oryzae'* the taxonomic identity of SCGS phytoplasma was always unclear and confusing. To address this question, we obtained whole-genome sequences of sugarcane grassy shoot (SCGS) phytoplasma

and Bermuda grass White leaf (BGWL) obtained using unique methods of enrichment of phytoplasma genomic DNA and targeted hybrid metagenomic assemblies of their leaf microbiomes. The enrichment of phytoplasma genomic DNA was confirmed by quantification of phytoplasma titre and removal of CpG-methylated host DNA using quantitative real-time PCR. The final SCGS, BGWL and PWB phytoplasma assemblies had 29 and 21 scaffolds respectively. The phylogenetic analysis of 16S rRNA gene (>1500 bp), nine housekeeping genes (>3500 aa), core genome phylogeny (>10,000 aa) and OGRI values were conducted to determine the phylogenetic position of SCGS phytoplasma. The orthoANI values for the strain SCGS against strains LW01 was 79.42 %, and dDDH values were 22. Overall analysis reveals that SCGS phytoplasma forms a distant clade in RYD group of phytoplasmas. Based on phylogenetic analyses and OGRI values obtained from the genome sequences, a novel taxon '*Candidatus* Phytoplasma sacchari' is proposed.

IL 11. Phytoplasma *diseases of coconut in India*

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Phytoplasma diseases pose a threat to coconut production globally. Root (wilt), tatipaka and lethal wilt are the important phytoplasmal diseases on coconut reported from India. Root (wilt) disease (RWD), first described by Sir EJ Butler in 1908, is a non-lethal debilitating malady reported a century ago from South Kerala and continues to remain as a threat to the coconut production in disease endemic tracts of Kerala and Tamil Nadu. Phytoplasmal etiology of RWD was established through electron microscopy, dodder transmission, antibiotic therapy and vector transmission. Association of '*Candidatus* phytoplasma oryzae' with RWD was further confirmed by molecular characterization. Two insects *viz*., lace bug (*Stephanitis typica*) and the plant hopper (*Proutista moesta*) were found transmitting RWD and their vectoral role was confirmed through electron microscopy and transmission studies. Owing to the exclusive phloem confinement, uneven distribution and sub-minimal titres of phytoplasma in palms, accurate and consistent diagnosis of RWD from coconut palm as well as vector is still a major challenge. Though nested PCR, LAMP and qPCR have been developed, refinement is required to enhance their sensitivity and specificity. Association of *Candidatus* phytoplasma asteris16Sr IB group phytoplasma with lethal wilt disease (LWD) of coconut reported recently from East Coast of Tamil Nadu is another concern to the coconut farmers. Studies from various monocots and dicots in coconut system could establish association of *Candidatus* Phytoplasma cynodontis -16SrXIV group and *Candidatus* Phytoplasma aurantifolia-16Sr II group, respectively. None of the studied weed hosts evinced the presence of RWD phytoplasma. Evolving robust diagnostic tools for consistent detection of RWD is very crucial in the holistic management of this disease. Transcriptomics to refine detection and metagenomics to evolve strategies for the sustainable management of the disease using microbiome is the need of the hour.

IL 12. Association of Phytoplasma-like organism (PLO) in Tapping Panel Dryness (TPD) of rubber (*Hevea brasiliensis)*

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Para rubber tree, *Hevea brasiliensis* (wild. exAdr. deJuss.) Muell. Arg. belongs to the family *Euphorbiaceae*, native to Brazil and is the most economically important member of the genus *Hevea* as it yields latex. The latex which is the cytoplasm of specialized cells of the bark is drained from the tree by controlled wounding. The latex collected from the tree is processed and used as a raw material for preparation of more than fifty thousand products directly or in blends.
Tapping panel dryness (TPD) is a serious disorder in all rubber growing countries, resulting in huge loss of latex yield. The disease is characterized by gradual drying of latex vessels on tapping panel, discoloration of bark resulting in abnormal low yield or complete stopping of latex production. TPD is of economic importance as the tree becomes non-productive causing reduction in the productive potential of the land area under cultivation. On an average 15-30% trees are affected in a cycle of plantation. Based on the current price of natural rubber, the loss in India due to TPD accounts for approx. 17 cores, every year. Some efforts were earlier made to investigate in to possible Physiological/Biochemical/Pathological factors associated with TPD. However, the cause of this disorder could not be conclusively established so far. Recent investigation on TPD-affected trees showed typical bark necrosis spreading downwards from tapping cut to root stock. DAPI (nuclear stain) stained TPD and healthy bark when examined under laser scanning microscope showed presence of a living organism in the phloem vessels and their absence in healthy bark. Phytoplasma enriched DNAwas isolated from TPD and few healthy bark samples. Nested-PCR assays using two universal primer pairs, R16mF2/R1 and R16F2n/R2 yielded an amplification of~13000bp in all TPD-affected plants. PCR amplification was obtained in certain healthy plants also. Cloning and sequencing of amplified PCR products were carried out and the sequences on optional blasting showed similarity to other reported Phytoplasmas. The healthy plants which were positive in PCR reaction later changed in to TPD. Scanning Electron Microscope (SEM) studies of Phytoplasma-positive bark samples showed round pleomorphic bodies similar to Phytoplasma in the sieve tubes. The size of the Phytoplasma- like bodies ranges between 400-2000 nm. This is the first report of the detection of Phytoplasma-like organisms from the rubber trees affected by TPD.

DO 01. Association of phytoplasma with bud proliferation of vegetable cowpea in Kerala

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Cowpea bud proliferation disease found in various locations of Kerala exhibited stunting of plants with smaller, crinkled and dark green leaves, abnormally proliferated bud which failed to produce flowers and pods with a disease incidence reaching up to 6.57 per cent. *Catharanthus roseus* grafted with infected cowpea plants developed symptoms like; interveinal chlorosis and yellowing with a transmission efficiency of 40 per cent. The mechanical transmission studies for viruses indicated absence of viruses. Ultra-thin sections of leaves and stem samples of infected cowpea samples stained with 4,6 -diamidino-2-phenylindole (DAPI), exhibited fluorescence. Serological detection for the viruses, *Cowpea aphid-borne mosaic virus* and *Blackeye cowpea mosaic virus* and *Tomato spotted wilt virus* and *Watermelon silver mottle virus* was negative for the symptomatic samples. The nested PCR yielded a 1.8 kb fragment with P1/P7primers and a 1.2 kb with the second set of primers; R16F2n/R16R2 and further sequencing and BLAST analysis of sequence revealed that the cowpea bud proliferation phytoplasma of Kerala is '*Candidatus* Phytoplasma asteris'-related strain. The virtual RFLP pattern derived from this 16S rDNA F2nR2 fragment was identical (similarity coefficient 1.00) to the reference pattern of 16Sr group I, subgroup B (GenBank accession: AP006628).

DO 02. Abundance of *Cand. Patescibacteria*: A novel microbial phylum in arecanut rhizosphere in YLD endemic areas

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Recently, the bacterial tree of life has undergone a tremendous expansion by the discovery of the immense microbial diversity within the 'candidate phyla radiation' (CPR). Recent phylogenetic and taxonomic analyses have suggested the reclassification of the CPR as a single phylum, *Cand. Patescibacteria*, an autotrophic phylum involved in nitrogen, sulfur and iron cycling. These organisms can metabolise sugar compounds under oxic and anoxic conditions. An examination of the structural composition of the arecanut rhizosphere microbiome, utilising 16s rRNA amplicon sequencing of arecanut palms from Yellow leaf Disease (YLD) endemic region of Sullia, Karnataka, reveals that higher abundance of phylum, *Cand. Patescibacteria* in the arecanut rhizosphere. These include Patescibacteria – *Cand. Parcubacteria, Cand. Moranbacteria, Cand. Kaiserbacteria, Patescibacteria ABY1-Cand.*

Magasanikbacteria, Cand. Kerfeldbacteria and *Patescibacteria-Saccharimonadia*. To date, only limited information is available about this phylum and its role in the rhizosphere niche environment. Hence this study warrants that research needs to be aimed at elucidating their ecophysiology to understand their abundance in the rhizosphere habitat of arecanut.

DO 03. Effect of plastic mulching on disease index and yield of yellow leaf disease affected arecanut (*Areca catechu* L.)

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Arecanut is affected by yellow leaf disease, which is a serious malady caused by Phytoplasma and transmitted by plant hopper *Proutista moesta*, and doesn't have a control measure. Field experiment was initiated in 2 farmer's gardens in Sringeri and 3 gardens in Sullia taluk in 2016 and 2017, respectively, to study the effect of plastic mulching on yellow leaf disease of arecanut. Plastic mulching during monsoon (June-September) reduced the disease index in all the three experimental plots in Sullia during the experimental period (2017 – 2020) compared to the pre-experimental data (2016 and 2017). It resulted in reduction of disease index in different gardens which had low initial disease index (2.9 – 5.8%). In Sringeri, disease index was higher (26.8%) with plastic mulch which had higher initial index (19.8%). It indicates that, plastic mulching is effective in reducing the symptoms when the initial disease index is low. The mean dry kernel yield during the four years of experimental period in Sullia was 1675 – 2061 kg ha^{-1} in mulched plots and 1284 – 1845 kg ha^{-1} in plots without mulching. The yield increase due to plastic mulching was 9.9 – 34% in different gardens. The cost of mulching varied from Rs. 2,03,875 to 2,51,250 per ha during the experimental period (four years). The additional net return due to mulching was Rs. 50,800 – 6,45,300. Maximum net return was recorded in plot with minimum disease index in 2020. Hence, plastic mulching is useful in combating the yellow leaf disease when initial disease index is low.

DP 01. Diversity of leaf hoppers in Marayoor Sandalwood (*Santalum album* Linn.)reserve affected with Sandal spike diseases (SSD)

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Indian sandalwood (*Santalum album* Linn.) is a hemiparasitic perennial tree which is accredited as *Royal Tree*of India and valued for its highly valuable scented heartwood and oil.The price of its heartwood and oil has risen significantly in the past decade mainly due to depletion of these trees in its natural habitatsby the infection of sandal spike disease (SSD).The present sandalwood reserve in Marayoor is facing huge loss of scented sandalwood majorly due to spread of SSD. SSD is caused by non culturable prokaryoticphytoplasma which is confined to phloem tissue and depend primarily on phloem feeding leaf hoppers as vectorfor their transmission from infected to a healthy plants. Though leafhoppers remain the most important vectors of phytoplasmas, unfortunately, information on vectors of SSD is scanty. A study was conducted at Marayoor reserve to understand the diversity of leafhoppers inhabiting in SSD affected areas. The study revealed the presence of 59 species of leafhoppers, belonging to five families viz., Cicadelliade, Fulgoridae, Issidae, Membracidae and Psyllidae.The present paper focused on the lacunae existing in the insect vectors of SSD and the need for determining the vectors for possible management of phytoplasma diseases in sandalwood trees.

DP 02. Molecular screening of citrus germplasm for simultaneous detection of *Candidatus* Liberibacter species associated with citrus greening disease

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North-eastern region of India is known as the home land for Citrus. In this region, many Citrus species originated and dispersed to various part of the world. Although it is the treasure home of various Citrus species, orchards in this region is significantly hampered by different biotic and abiotic stresses. Among these maladies, citrus greening is the most devastating one, which causes extensive destruction of citrus orchards all over the world. A small part of this scattered Citrus diversity is maintained as ex-situ collection of the germplasm in CRS Tinsukia. The current research study was aimed to screen, understand the response of those accessions to prevalent *Candidatus* Liberibacter populations associated with Citrus greening (CGD) in Assam under natural challenge conditions. Overall, 32 germplasm were screened comprising 16 species, 1 hybrid and 1 unidentified cultivar. The severity of CGD based on symptomatology showed

that; major parts of the germplasm were infected with CGD. The conventional PCR assay with specific primer of these varieties showed that, only three (3) varieties namely; Khasi Papeda, Trifoliate Orange and Citrange are free from CGD infection. Comparative quantification of infected (10 samples) and suspected healthy (3 varieties) were done by Real time PCR to differentiate the known *Ca*. Liberibacter species in a singleplex reaction. The assay confirmed that the suspected healthy accessions were resistant and the others were infected with only *Ca*. Liberibacter asiaticus. The sequence similarity and evolutionary divergence analysis of the CGD isolates showed sequence similarity with the '*Ca*. L. asiaticus' isolates from Southeast Asia, rather than the other diverse.

DP 03. *Candidatus phytoplasma aurantifolia* associated with sesamum phyllody in Kerala

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Onattukara is the traditional sesamum cultivating area of Kerala practising an intensive multiple cropping system with a cropping sequence of paddy-paddy-sesamum. Sesamum is the sole crop in summer rice fallows of Onattukara tract. Phyllody, caused by phloem limiting phytoplasmas is a serious disease of sesamum. An incidence of 39.44 per cent was recorded in Karthikapally taluk. The associated symptoms were virescence, phyllody, reduction in internodal length, thickening of floral veins and floral proliferation. Chocolate weed, *Melochia corchorifolia* exhibited symptoms of shoot proliferation and hoppers collected from infected fields were identified as *Orosius albicintus*, *Hishimonas phycitis* and *Nephotettix* sp. Microtome sections of infected and healthy tissues of sesamum stained with 4,6-diamidino-2-phenylindole (DAPI) stain emitted diffuse fluorescence from infected tissues indicating the presence of phytoplasma. Molecular characterization of sesamum phyllody was performed with leaf samples collected from ORARS lowland, upland and Karthikapally. Amplicons of 1.4 kb was obtained by amplifying the isolates with universal primers P1/P6 for detection of phytoplasma. The BLAST analysis showed that all the isolates shared more than 99 per cent sequence similarity with '*Candidatus* phytoplasma aurantifolia' strains in GenBank data base. In the phylogenetic tree constructed, the phytoplasma under study clustered with 16SrII group phytoplasmas causing sesamum phyllody in various regions. The virtual RFLP pattern was identical to the reference pattern of 16Sr group II, subgroup D. Based on the results obtained, the phytoplasma associated with sesamum phyllody in Onattukara tract was identified as "*Candidatus* Phytoplasma aurantifolia"-related strain belonging to subgroup 16SrII-D.

TECHNICAL SESSION 5

DISEASE MANAGEMENT - HOST PLANT RESISTANCE, CHEMICAL AND BIOLOGICAL CONTROL

Chairperson	:	Dr. Yasoda Hegde, Professor, UAS, Dharwad
Co-chair	:	Dr. Devappa, V., Prof & Head, UHS, Bengaluru
Convener	:	Dr. Iswara Bhat, A., Principal Scientist, ICAR-IISR
Rapporteurs	:	Dr. Merin Babu, Scientist, ICAR-CPCRI and Dr. Praveena, R., Scientist, ICAR-IISR

LL 05. Microbiome engineering - A systems biology approach in crop disease management

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Crop plants are macro-organisms which are associated with diversified species of micro-organisms such as bacteria fungi and viruses and create a complex system. Beneficial microbes in the microbiome of a plant serves several purposes such as germination, growth promotion, development and stress tolerance. On the other hand, pathogenic microbes in the microbiome interact with the host to cause diseases. Genomic, transcriptomic and proteomic approaches have helped in understanding the composition, function, networking and interaction of plant microbiomes. Pathobiome (pathogenic microbes within a plant) are also known to interact and network. Furthering our understanding through these observations, one disease – one pathogen hypothesis might change in the science of plant diseases. Population of plant pathogenic and plant beneficial microbes inside the endophytic environment was also reported to be inversely related. Overall microbiome and pathobiome compositions also vary depending upon the plant growth stage and found to be organ specific as well as influenced by the external environment. Exploring the complex microbial community in every crop plant across spacio-temporal variations and arriving at a blue print of microbiome beneficial to the given crop is essential to develop strategies of plant disease control under field conditions. Microbiome engineering which manipulates the holobiont, is an emerging biotechnology for improving plant disease resistance and increasing the agricultural yield. New biocontrol agents along with growth promoting microbes identified through the metagenomic sequencing would help to engineer the microbiome when applied as a consortium through seed or soil. Out numbering of pathogenic microbes in the microbiome by biocontrol agents and functional suppression through metabolic activity and antagonism in the engineered microbiome would be the expected mechanism of function by the engineered microbiome in plant disease management at the field level.

IL 13. Significance of viral diseases of cucurbitaceous vegetable crops in Tamil Nadu and its management through IPM strategies

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Cucurbitaceous vegetables contribute nearly 20 per cent of total vegetable production in India. The total production of cucurbitaceous vegetables is around 6.5 million tonnes contributing about 74% of total production in South Asia. Tamil Nadu is one the major states in

India producing different types of cucurbitaceous vegetables from different agro- ecological zones by subsistence farmers to meet the increased demand for vegetable consumption in the country. Around 60 different viruses were reported to be infecting wide varieties of cucurbitaceous vegetable crops worldwide. These viruses produce different types of symptoms *viz*., mild to severe forms of mosaic, mottling, puckering and blistering of leaves, reduced leaf size, various types of leaf deformations, malformation of fruits and stunting of plants. Quite a few new records on viral diseases are documented for the first time in India on cucurbits in the field survey conducted during last couple of years in Tamil Nadu. *Cucumber mosaic virus* (*Cucumovirus*) infecting on bottle gourd and snake gourd belongs to subgroup IB showed close relatedness with an Italian isolate than Asian isolates, which was recorded for the first time in India. Similarly, *Zucchini yellow mosaic virus* (*Potyvirus*) having 99 per cent identity with an Iran isolate has also been documented on snake gourd and pumpkin for the first time. *Cucumber green mottle mosaic virus* (*Tobamovirus*) possessing 98 per cent identity with France and Japan isolates causing the mosaic mottling with reduced leaf size and phylloid flowers on snake gourd. *Papaya ring spot virus* (*Potyvirus*) causing mosaic disease on ivy gourd was documented for the first time from Southern India having maximum identity (86.6 per cent) with France and Thailand isolates. In addition to these RNA viruses, a novel bipartite begomovirus, *Coccinia mosaic virus* causing mosaic disease on ivy gourd was documented. *Tomato leaf curl New Delhi virus* (*Begomovirus*) causing mosaic and enation on chayote was also documented for the first time from Southern India. Documentation of the new viruses and existing viruses on new hosts represented the expansion to new geographic horizons and host range. Most of these virus isolates showing maximum identities with exotic isolates are known to be transmissible through seed as well. Consequently it is indispensable to increase awareness of virus spread and encouraging commercial seed supply chains to supply virus-free seed to farmers for the production of cucurbitaceous vegetables with high nutritive value.

Due to the lack of curative measures, virus diseases can be managed by a combination of integrated disease management strategies in an environmentally benign manner. Indiscriminate use of pesticides is resulting in pesticide resistance in insect vectors. Consequently, we sought to develop IPM strategies for the concurrent management of the virus diseases in subsistence agriculture. A combination of management practices viz., seed and soil treatment with plant growth promoting rhizobacterium, *Pseudomonas fluorescens* / *Bacillus subtilis*, roguing virus-infected plants, installing yellow sticky traps and need based applications of neem formulations was tried as a package. The white fly transmitted Begomoviruses, aphid transmitted Potyviruses and *Cucumber green mottle mosaic virus* are the major threaten for the cucurbitaceous vegetable production in Tamil Nadu. In order to develop the IPM module for the efficient management of these virus diseases, farmer's participatory field trials were conducted at different locations in different cucurbit crops with an IPM module involving, seed and soil application of *Pseudomonas fluorescens* / *Bacillus subtilis*, soil application of neem cake, soil drenching with humic acid, foliar spray with zinc sulphate and boron @ 0.1%, installation of yellow sticky traps

and need based applications of neem formulations. The results revealed that the IPM plots recorded significantly lower virus disease pressure with higher fruit yield than farmers practice.

The basal soil application of micronutrient mixture @ 2.5kg / ha each of ferrous sulphate, zinc sulphate, copper sulphate, manganese sulphate and borax along with the foliar application of micronutrient mixture (0.2 per cent of each ferrous sulphate, zinc sulphate, copper sulphate, manganese sulphate and 0.1 per cent borax) along with application of *Bacillus subtilis* to seed and soil were found to be significantly effective in reducing the incidences of virus diseases in gourds besides increasing the fruit yield. The farmers participatory field trials for the integrated management of *Water melon bud necrosis virus* (WBNV) in water melon with an IPM package (seed and soil application of *Pseudomonas fluorescens*, soil application of neem cake, soil mulching with white / black polythene sheet, growing maize as border crop, installation of yellow sticky traps and application of botanical pesticides) was found to be effective in reducing the WBNV incidence.

IL 14. Advances in bio-pesticides and its application in field, horticulture and forest crops for sustainable plant disease management

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Plant diseases are among the main constraints affecting the production and productivity of crops both in terms of quality and quantity. Biological control is more relevant today than it has been. Stand alone bio-control agents and products are now available for management of various field, horticulture and forest crop diseases. The use of natural antagonists to combat plant diseases has emerged as a promising alternative to chemical pesticides. As the microbial bio-control agents express complex mode of action and at present microbial agents viz. viruses, bacteria, nematodes, and fungi; used globally with higher advantage and success. Management of leaf spot disease of mappia caused by *Cylindrosporium mappiae* revealed the significant effect of use of fungal antagonist *Trichoderma harzianum*, (IOF strain) followed by *Trichoderma viride*, *Trichoderma koengii*. The bacterial biocontrol agent *Pseudomonas fluorescens* (IOF strain) and *Bacillus subtilus* (IOF strain) were found superior under invitro studies. The minimum terminal disease severity for fungal foliar diseases of ground nut was recorded in sequential application of bioagents (Tri*choderma harzianum –Pseudomonas fluorescens – Bacillus subtilis*) and also significantly enhanced the plant growth and yield parameters, thereby recorded the highest B:C ratio. The oil based formulation of *P. fluorescens* was found effective in reducing the foot rot disease severity in Wheat as well as maximum plant height and yields and B:C ratio was recorded in oil based formulations of *P. fluorescens* as seed treatment followed by spray. The combination sprays of *Pseudomonas fluorescens* and *Bacillus subtilis* @ 5 g per litre three times at an interval of 15 days recorded highest reduction of powdery and

downy mildews of cucumber and increased the yields, increase in plant height as compared to sole applications under protected cultivation, which has resulted in highest gross returns, net returns and highest benefit-cost ratio. The seed treatment with *Bacillus subtilis* and *Pseudomonas fluorescens* @ 5 g/kg followed by seedling dip with *B. subtilis* and *Pseudomonas fluorescens* @10 g/l fb spray with *B. subtilis* and *Pseudomonas fluorescens* 4 times at 15 days interval has considerable reduced the early blight, septoria leafspot and powdery mildew diseases of tomato under protected cultivation. Use of consortium of biocontrol agents is the best way of enhancing or synergizing the efficiency of bioagents instead of using them singly. In an experiment of using consortium, it is reported that bacterial and fungal antagonists combined with AM fungi are found more useful for managing tree diseases appearing in seedling stage. It is also important to encourage local species / strains for their efficacy. The talc based microbial consortia consists of *Trichoderma harzianum* + *Pseudomonas fluorescens* + *Bacillus subtilis* + *Neofusicoccum purvum* (an endophyte) was found promising in the management of foot rot of wheat.

IL 15. Advances in breeding for resistance against crop diseases with special reference to soybean varieties in India

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The development of scientific agriculture by man and development of plant diseases have been on parallel lines since the very beginning of crop production. The achievements made in food production in the developing countries by **"Green Revolution"** can be maintained only if proper importance is given for the plant protection strategies. The management of diseases is not possible through only one approach. In recent years different management practices are employed like biological control, chemicals, eradication, quarantine measures and resistant varieties etc., which led to the emergence of the new area called **Integrated Disease Management**. Agriculture is influenced by an array of biotic and abiotic stresses, which are be managed through multipronged strategies. A strategic science based approach is needed to address the plant health risks and issues that affect productivity. The looming threat of climate change may further exacerbate the crop losses due to insect pests and diseases. The integrity of agroecosystem is vital for sustainable agriculture. The indiscriminate use of chemical pesticides has been causing wide spread environmental pollution, resistance, resurgence of insect pests and is impacting food safety. Plant Health Management is vital for the sustainable agriculture, food security, food safety, agro based industries and economy of a country.

The recent advances made in understanding **host-pathogen interaction** include most frequently sensing molecules outside the cell and the other most frequently sensing molecules inside the cell. Understanding of heritability and genetics, developed in the early 20th century, allowed researchers to identify sources of heritable resistance called resistance genes (R genes).

R genes were further described by Harold Henry Flor's ground breaking gene-for-gene model. The advances in molecular techniques and genomics of the early 21st century drove the discovery of numerous classes of genes that encode regulators of disease resistance and susceptibility. Recent molecular research has revealed that plant resistance relies on a complex regulatory system that controls plant defense responses, greatly built upon the simple structure of H. H. Flor's gene-for-gene model. Plant immune system components participate in pathogen detection, signal transduction, or defense response.

There are two systems detect different types of pathogen molecules and classes of plant receptor proteins. The first tier is primarily governed by pattern recognition receptors that are activated by recognition of evolutionarily conserved pathogen or microbial–associated molecular patterns (PAMPs or MAMPs). Activation of Pattern Recognition Receptors (PRRs) leads to intracellular signaling, transcriptional reprogramming, and biosynthesis of a complex output response that limits colonization. The system is known as PAMP-Triggered Immunity or as Pattern-Triggered Immunity (PTI).The second tier, primarily governed by R gene products, is often termed effector-triggered immunity (ETI). ETI is typically activated by the presence of specific pathogen "effectors" that triggers strong antimicrobial responses, **RNA silencing** and **Systemic Acquired Resistance** elicited by prior infections. There are several reports on suppressing the diseases in crops like soybean, tobacco, cotton etc.

Soybean diseases are major stumbling blocks in successful raising of crop and achieving the highest productivity. Among the various management options available, breeding for resistance a long term and sustainable approach. In this, we summarise here the efforts made in development of resistant varieties of soybean against major diseases mainly rust, purple seed stain and pod blight complex. Rust in Karnataka was severe and caused losses up to 20-80 per cent in JS-335 depending on its severity, stage of occurrence and favourable climatic conditions in northern Karnataka. In recent years, soybean anthracnose has become one of the major production constraints in all soybean growing areas of India. The loss due to this disease in India has been reported to an extent of 16-25 per cent in seed yield apart from affecting seed quality. The research efforts on development and release of rust resistant varieties in India over a decade has lead to development and release of first ever rust resistant and high yielding variety DSb 21 for the state of Karnataka and also south India during 2013. Later, DSb 23 and DSb 28-3 highly rust resistant and high yielding varieties which have recommended for cultivation for Southern Zone (Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh and Telangana States) during 2015and 2017.Out of 19 genotypes, the genotypes *viz.*, DSb 12, DSb 20, DSb 23-5 and Kalitur were found highly resistant with a disease grade of one to pod blight complex.. The genotype JS 335 was highly susceptible to anthracnose with a maximum disease grade of nine. Among the markers used, Satt 275 showed polymorphism for both the parents (EC 241780 and JS 335) as well as other genotypes. The amplified PCR product of genotypes with polymorphic marker Satt 275 was sequenced and most of the sequences scored an E value of 0.031 and an identity of 90 per cent with the mRNA sequence of the *Rpp*5 gene. The classification results revealed that the

sequence of the advanced line DSb 30-2 showed the highest degree of identity with the concerned *Rpp5* like disease resistance mRNA sequence.

EO 01. Effect of biocontrol agents on growth and development of black pepper infected with *R. similis* and *P. capsici*

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The field experiment was carried out in the farmer's field for two years, with a view to evaluate bioagents (*Trichoderma harzianum*, *Purpureomyces lilacinum*, *Pseudomonas fluorescens* and *Bacillus substilis*), organic amendment (Neem cake) and chemicals (Carbofuran and Bordeaux mixture) separately and in combination for the management of *R. similis* and *P. capsici* A field experiment was conducted for the management of *R. similis* and *P. capsici* wilt complex in black pepper. Among combination treatments of bioagents, organic amendments and chemicals, maximum number of runner shoots was observed in plants with Bordeaux mixture (1 %) spray + soil application of *T. harzianum* (50 g) with 27.33 followed by Bordeaux mixture (1 %) + *P. lilacinum* (50 g) recorded 25.00 and it was on par with 24.33 number of runner shoots in Bordeaux mixture (1 %) + *P. fluorescens* (50 g). lowest number of runner shoots was observed in Bordeaux mixture (1 %) + Carbofuran-3G (15 g) treated vines with 19.66 number of runner shoots and it was on par with Bordeaux mixture (1 %) + Neem cake (2 kg) with 20.33 number of runner shoots. Among the individual treatments, maximum number of runner shoots (16.33) was observed in *T. harzianum* (50 g) and lowest number of runner shoots (7.33) in untreated control. Highest number of spikes was produced in the vines treated with Bordeaux mixture (1 %) +*T. harzianum* (50 g) with 321.33 followed by Bordeaux mixture (1 %) + *P. lilacinum* (50 g) which recorded 294.66 number of spikes and lowest number of spikes was produced in untreated control plots (89.33) followed by 151.33 in Carbofuran-3G (15 g) respectively. With respect to spike length, all the treatments were on par with each other. Vines treated with Bordeaux mixture (1 %) +*T. harzianum* (50 g) and Bordeaux mixture (1 %) + *P. lilacinum* (50 g) recorded maximum spike length of 17.66 cm respectively and it was on par with vines treated with T_3: Bordeaux mixture (1 %) + *P. fluorescens* (50g) (16.66 cm) and Bordeaux mixture (1 %) + *B. subtilis* (50 g) (15.66 cm). Lowest spike length was observed in vines with untreated control (7.66 cm) and it was on par with Carbofuran 3G (15 g) (8.33 cm) and *B. subtilis* (50 g) (8.66 cm).

Highest spike weight was recorded in Bordeaux mixture (1 %) + *T. harzianum* (50 g) with 2992.00 g followed by Bordeaux mixture (1 %) + *P. lilacinum* (50 g) with 2760.66 g and lowest spike weight was recorded in untreated control (1072.66 g) and it was on par with Carbofuran 3G (15 g) (1241.66 g). Vines treated with Bordeaux mixture (1 %) spray + *T.*

harzianum (50 g) recorded maximum dry berry weight of 2.27 g / vine and it was on par with vines treated with Bordeaux mixture (1 %) + *P. lilacinum* (50 g) with 2.05 g/vine. However, untreated control vines recorded lowest dry berry weight (0.63 g) and it was on par with Carbofuran 3G (15 g) (1.04 g).

EO 02. Biocontrol potential of endophytic bacteria for the management of web blight of cowpea incited by *Rhizoctonia solani* Kuhn.

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Web blight caused by *Rhizoctonia solani*, is become a severe problem in cowpea growing tracts. The web blight appears every year at varying intensity and leads to drastic yield loss. The effectiveness of current management strategies was often limited by the emergence of new races of the pathogen. Application of endophytic bacteria as biological control agents (BCA) can be an eco-friendly approach in sustainable agricultural practices for the management and suppression of plant diseases. Thirty - eight endophytic bacteria were isolated from healthy root, stem and leaves of fodder cowpea var. Aiswarya (22 isolates) and bush cowpea var. Bhagyalakshmi (16 isolates). Based on the results of dual culture assay and culture filtrate assay isolates CFLE3, CBRE5 and CBSE5 were selected as promising ones for further *in vivo* studies. Thus, three promising endophytic bacterial isolates were tentatively identified as genus *Bacillus* based on the morphological, cultural and biochemical characters. The species identity of isolates were confirmed through 16S rRNA analyses as *Bacillus subtilis* (CFLE3), *B. amyloliquefaciens* (CBRE5) and *B. velezensis* (CBSE5). In pot culture experiment the lowest disease index occurred in plants treated with seed biopriming for 4 h along with foliar application (20 and 40 DAS) of *B. velezensis* CBRE5 with 54.91 % disease suppression. Production of ammonia and siderophore were also investigated for elucidation of their antifungal activity. This study suggesting that these selected endophytic bacteria are potential to be developed as biocontrol agents.

EO 03. Yesteryears in coffee leaf rust disease and management strategies in India

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Coffee leaf rust disease established throughout the coffee areas of Peninsular India and has remained as a major limiting factor in coffee production ever since18th century. The greater parts of the coffee area nearly 90% lies in the areas dominated by South-West monsoon, the

remaining is mainly at higher elevations at about 4000 feet and above in the North-East monsoon dominated areas. Climatic factors like temperature, relative humidity, sun shine hours, wind and rainfall play a major role in build-up of disease on the coffee bushes which in turn reflects on the increase or decrease of leaf rust incidence in a season apart from the inoculum. Agronomic practices like spacing, pruning, training of coffee bushes, application of balanced nutrients and diversity of genetic materials plays actual significant role in CLR management in India. During 1920 onwards spray of 0.5% Bordeaux mixture twice a year i.e., pre-monsoon (May to June) and post-monsoon (September to October) found effective to manage CLR disease. As climatic situations vagaries and improved assorted genetic material, pathogen *Hemileia vastatrix* too developed novel physiological races. This enforced the researchers to improve the CLR management policies with systemic fungicides *viz.*, oxycarboxin, carboxin, triadimefon, propiconazole, hexaconazole, tebuconazole, epoxiconazole and various combinations of strobilurins and triazoles. Ecofriendly management with use of mycoparasite *Verticillium hemileae*, PGPR's like *Bacillus subtilis*, *Bacillus magaterium* and also botanicals were studied. Finally, integrated the effective management practices as Integrated Disease Management package was developed and popularized in the planting community to minimize the crop losses caused by CLR disease.

EO 04. Biotic and abiotic elicitor mediated induced systemic resistance against pearl millet downy mildew

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Pearl millet (*Pennisetum glaucum* (L.) R. Br.), is an important cereal crop, the main biotic constraint for the production of pearl millet is mainly by downy mildew caused by *Sclerospora graminicola* (Sacc.). We are reporting the immunity eliciting properties of Cell Wall Glucan (CWG), Lipopolysaccharide (LPS), and Glycinebetaine (GB) was deciphered through enzymatic and protein studies based on elicitor treatment activated defense mechanisms. GB, LPS, and CWS and elicited enzyme activities and gene expression of defense enzymes like β-1,3-glucanase, Phenylalanine ammonia lyase (PAL), Peroxidase (POX), Polyphenol oxidase (PPO), Lipoxygenase (LOX) and defense protein Hydroxyproline-rich glycoproteins (HRGPs). However, the speed and the extent of elicitation differed. High levels of enzyme activities and gene expression in elicitor-treated pearl millet positively correlated with increased downy mildew resistance. The very rapid and large changes in elicitor-treated seedlings, in contrast to the delayed, smaller changes in the untreated susceptible control seedlings suggests that rate and magnitude of defense gene expressions are important for the effective manifestation of defense. For most of the enzymes and proteins tested, GB promoted increase in enzyme and gene

activities in a more accentuated way and faster than other elicitors and control, implicating that GB is a promising elicitor of downy mildew resistance in pearl millet.

EO 05. Characterization of genes encoding for antimicrobial properties of *Bacillus safensis* and evaluation of its biocontrol efficiency against rhizome rot pathogens of turmeric

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Biosynthetic genes that encode for the production of antimicrobial peptides (AMP) such as, 2,4-diacetylphloroglucinol (DAPG), pyrrolnitrin (PRN), pyoluteorin (PLT), bacillomycin D, fengycin, the volatile metabolite, HCN and the gene responsible for the production of lytic enzyme, cellulase were analyzed in shortlisted rhizobacterial isolates using gene-specific primers. The most promising Plant Growth-Promoting Rhizobacterial (PGPR) strain, *Bacillus safensis* (NCBI- MT192800) with maximum biocontrol efficiency showed the presence of the bacillomycin, surfactin, iturin, fengycin and pyoluteorin. The isolate produced indole 3-acetic acid, NH_3, HCN, siderophore, cell wall degrading enzymes (cellulase, protease and pectinase) and also exhibited the capacity to solubilize inorganic P, Zn and K. The isolate also exhibited remarkable suppression of various fungal pathogens infecting turmeric *viz*., *Pythium myriotylum*, *P. aphanidermatum*, *Colletotrichum gloeosporioides, C. capsici*, *Macrophomina phaseolina* and *Fusarium oxysporum* under *in vitro* conditions. Green house experiments with turmeric plants challenge inoculated with these fungal pathogens showed that Percent Disease Index (PDI) was significantly lowered in treatments with the bacteria compared to the chemical method. *B. safensis* application also exhibited improved germination, plant growth and rhizome yield. Our findings indicated that the potential of this *B. safensis* strain, IISR-TB4 to suppress multiple fungal pathogens, solubilize P and promote plant growth could be further exploited to reduce the dependence on chemicals for sustainable cultivation. Data from field experiments also suggested that the B. *safensis*strain could be commercialized for plant growth promotion and management of turmeric rhizome rot disease. The dominance of biosynthetic genes in shortlisted rhizobacterial strains also supports the competitive role of AMP in enhancing fitness of these strains under normal environmental conditions.

EO 06. Navigating complexity to breed for disease-resistant clones of rubber (*Hevea brasiliensis*) by screening germplasm accessions and assessing their genetic diversity using Genome-wide SNP markers

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Rubber tree suffers from a variety of diseases resulting in significant economic loss. *Phytophthora* spp., *Corynespora cassiicola* and *Colletotrichum* spp. are the major pathogens causing diseases in rubber tree. The use of disease resistant clones possessing high productivity is the most promising method for disease management. Screening of all available resources, including cultivated clones, wild accessions and progenies raised through crossing experiments, to identify tolerant lines is the elementary prerequisite for initiating any resistance breeding programme. A collection of 200 Wickham clones, five *Hevea* species and $86F_1$ progenies derived from an interspecific cross between *H. brasiliensis* (high yielder but susceptible to major diseases) and *H. benthamiana* (low yielder but tolerant to major diseases) were evaluated for their disease resistance to these three major pathogens and were categorized based on their level of disease tolerance. Clones belonging to highly tolerant group were identified for their useas donor material in order to develop tolerant varieties that withstand multiple pathogen stress in addition to being a high yielder. Evolutionary relationship was studied using 12,078 genome-wide SNP markers derived through genotyping by sequencing technique among 116 clones belonging to *H. brasiliensis* (54 from Malaysia, 51 from India, five from Sri Lanka, four from Indonesia and two from China) and six species of *Hevea*. The phylogenetic tree constructed helped to understand population structure better at the level of genetic differentiation among groups within the Wickham clones. These Wickham clones of rubber, serve as a reliable source of germplasm incorporating multiple and diverse resistance genes from plants belonging to different spatial and temporal scales. This wisdom is being used to comprehend population stratification, determine the degree of evolutionary divergence and in association mapping studies in order to identify markers associated with disease resistance for their use in MAS.

EO 07. Exploring the potential of oil based formulation of *Pseudomonas fluorescens* against *Bipolaris sorokiniana* causing spot blotch of wheat and its quality content

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Liquid formulations has numerous merits such as high cell count, prolonged shelf life, enhanced protection from environmental stresses and improved field efficacy. *Pseudomonas* spp. are the plant growth-promoting rhizobacteria (PGPR), which are vastly used for boosting growth of the plant and disease control. In order to enhance the efficacy of this bacterial bioagent, it must be prepared as formulations so that it sustain s sufficient bacterial population for a longer period of time and ensures its easy application, storage and field use. Spot blotch of wheat is both seed and soil borne disease which is transmitted by seed themselves in nature. In Karnataka,

about 60 per cent of area is under tetraploid wheat which comprises *Triticum durum* and *Triticum diccocum*. *Triticum diccocum* is more susceptible to spot blotch disease. Spot blotch disease is gaining considerable importance in Karnataka because of severe outbreak year after year and larger area occupied. Field experiments revealed that minimum disease severity (24.69 %) was recorded in treatment (seed treatment with canola oil - based formulation @10ml/kg - spray of canola oil -based formulation @ 0.5 %) which was significantly superior over the other treatments involving different oil -based formulations, talc based formulation and untreated control. Plant height, yield and quality parameters of wheat grain were significantly enhanced in all the treatments containing *P. fluorescens* formulation compared to untreated control. The highest yield (11.29 q/ha), B:C ratio (1:1.34), GPC (11.44 %), WGC (33.16 %) and GI (92.64 %) were recorded in the canola oil -based formulation. Thus indicating the role of *Pseudomonas fluorescens* in activating genes responsible for defense in the plant system and also growth promotion ability.

EP 01. Antifungal activity of volatile organic compounds produced by *Bacillus cereus* against fruit rot caused by *Colletotrichum truncatum* on chilli

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Chilli is one of the most important spice and vegetable crop which is adversely affected by fruit rot caused by *Colletotrichum truncatum*. Due to an increasing concern about human health and environmental security, antagonistic microorganisms have been a potential alternative for fungicides to control postharvest diseases. In this study, the antifungal effect of volatile organic compounds (VOCs) produced by *Bacillus cereus* Bc- ADP against fruit rot pathogens isolated from chilli fruit *Colletotrichum truncatum* was evaluated by *in vitro* experiment. As a result, the VOCs released by Bc- ADP was able to suppress the mycelial growth of all targeted pathogens according to inhibition ratio in the petri-dish assay. The main volatile compounds were identified by GC-MS analysis. These VOCs produced by the *Bacillus* strain played complementary roles in controlling the fruit rot fungi. This research will provide a theoretic foundation for exploring the functional components of VOC.

EP 02. Microencapsulation: A novel method to deliver *Pseudomonas fluorescens* for management of soil borne pathogens

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Inoculation of plants with microorganisms to control plant diseases has been practiced for several decades. *Pseudomonas fluorescens* is one such biocontrol agent which is used to combat many phytopathogens. For commercial application, microbial inoculum should be supported by appropriate formulation preventing rapid decline of introduced biocontrol agents and extending their shelf-life. A method of entrapping biocontrol agent using sodium alginate as a substrate and *Pseudomonas fluorescens* as the model biocontrol agent was developed. The microbeads were produced when alginate solution mixed with liquid bacterial culture suspended in King's B medium supplemented with additives through a separating funnel resulting in small-diameter droplets. These droplets, when sprayed into a slowly stirred solution of CaCl2, immediately hardened into microbeads at diameter ranging from to. Microbeads were produced in three batches *viz.*, alginate beads, skim milk beads and beads after secondary multiplication. It was observed that alginate beads were more effective than skim milk beads and beads after secondary multiplication. Although this process killed part of the entrapped bacteria, the remaining bacteria residing per alginate bead were found to be [>1012 colony-forming units (CFU) bead-1]. High viability of the encapsulated bacteria was observed with upon storage for 4 months. Steady and constant cell release from the bead was observed for 1 week. The prepared alginate beads were found inhibiting major soil borne plant pathogens under *in vitro* conditions.

EP 03. Microbial consortia for the management of foot rot of wheat caused by *Sclerotium rolfsii* Sacc.

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The microbial consortia are getting paramount importance in crop production and protection. Application of bioagents as a consortium may improve efficacy, reliability and consistency of the bioagents even under diverse soil conditions. Foot rot of wheat caused by *Sclerotium rolfsii* Sacc. is a major problem in the rainfed area s of Karnataka. The pathogen is soil borne and damaging the crop by causing pre and post emergence death from seedling stage to maturity of the crop. In the pot experiment the bioagents (single and consortia) were inoculated by adopting two methods of applications (seed treatment alone and seed treatment followed by soil drenching) for the management of foot rot of wheat. The highest disease reduction and maximum plant growth parameters (root length, shoot length and number of leaves) were recorded in microbial consortia treated with seed treatment followed by soil drenching. The minimum disease incidence was found in consortium of *T. harzianum* + *P. fluorescens* + *B. subtilis* + *N. parvum* (26.67%) compared to all other treatments and maximum disease incidence was recorded in *P. fluorescens* (63.33%) in seed treatment followed by soil drenched pots. The pots treated with seed treatment alone has shown minimum disease incidence

of 16.67 per cent in consortium of *T. harzianum* + *P. fluorescens* + *B. subtilis* + *N. parvum* and maximum disease incidence was found in *P. fluorescens* (66.67%). While 96.67 per cent of foot rot disease incidenc e was recorded in the untreated control. This indicates the antagonistic nature of microbial consortia to manage soil borne disease.

EP 04. *In vitro* evaluation of new molecules of fungicides against purple blotch *Alternaria porri* (Ellis) Cifferi of garlic (*Allium sativum* L.)

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Garlic (*Allium sativum* L.) is the second most widely cultivated bulb crop after onion and susceptible to number of diseases at various stages of plant growth. Among them, purple blotch caused by *Alternaria porri* (Ellis) Cifferi, is the most destructive disease of garlic. In the present study various new molecules of contact, systemic and combi product fungicides were tested against *Alternaria porri* by poison food technique at different concentrations. The contact fungicides were tested at three concentrations (0.1, 0.2 and 0.3 %), observed maximum per cent mycelial growth inhibition with mancozeb 75% WP (62.84, 74.81 and 76.42 % respectively). In systemic fungicides, three concentrations (0.05, 0.1 and 0.15 %) were tested and observed cent per cent inhibition with propiconazole 25% EC at three concentrations. The cent per cent inhibition was also noticed in tebuconazole 250 EC only at 0.15 per cent concentration. Among the combi product fungicides tested at three concentrations (0.05, 0.1 and 0.2 %), maximum inhibition of mycelial growth (100 %) was noticed in fluopyram 17.7 % + tebuconazole 17.7 % (Luna Experience 400 SC) at three concentrations and found to be most effective and significantly superior over rest of the combi product fungicides. Present finding suggests that fluopyram 17.7 % + tebuconazole 17.7 % SC and propiconazole can be used in management practices for the control of purple blotch of garlic.

EP 05. Impact of foliar application of fungicides and biocontrol agents on tomato leaf bacterial community structure revealed by metagenomic analysis

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Fungicides are commonly used to manage plant pathogens. However, little is known about their effects on the nontarget fungal communities that inhabit inside and outside the plant. Hence, an amplicon metagenomic approach based on 16S rRNA gene on the MiSeq Illumina platform was used to study the impact of foliar application of two fungicides (propineb and iprodione + carbendazim) and a plant growth promoting microbial consortium (PGPM mix) on non-target tomato leaf bacterial communities, in the context of early blight disease management. Metagenomic analysis revealed that the richness and diversity of tomato leaf fungal populations were adversely affected by the chemical treatments tested while bioagent application enhances microbial population and diversity. Among the two fungicides, propineb (contact fungicide) imparted less non-targeted effects on bacterial population than iprodione + carbendazim (systemic fungicide). Metagenomic studies also revealed a new mode of action for fungicides and bioagents besides their direct effect that is shifting the microbial community structure so that it provides greater resistance against the pathogen.

EP 06. *In-vitro* evaluation of bioagents against leaf spot of ginger caused by *Phyllosticta zingiberi* Ramakr

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Ginger (*Zingiber officinale* Rosc.) is an important tropical spice belonging to the family *Zingiberaceae*. Among the diseases in ginger *Phyllosticta* leaf spot caused by *Phyllosticta zingiberi* Ramakr is considered to be destructive, appearing in mild or severe form in all ginger growing tracts of the country. Efficacy of six bioagents *viz., Trichoderma viridae, T. harzianum, T. asperellum, T. longibrachiatum, Bacillus subtilis and Pseudomonas fluorescens* were tested against the five isolates (MND (Mandya), HSN (Hassan), RNP (Ramanathapura), HNP (Holenarasipura) and PYP (Periyapatna)of the pathogenusing dual culture technique. There was a significant difference in per cent mycelial inhibition of the isolates among the bioagents tested. *B. subtilis* recorded 100 per cent mycelial inhibition of all the isolates, similarly *P. fluorescens* in three isolates *viz.,* RNP, HNP and PYP. Among *Trichoderma* spp. tested, *T. viridae* recorded highest per cent mycelial inhibition of 80.37 per cent in HSN and 73.33 in MND isolate followed by *T. longibrachiatum* (71.11 % in HNP and 70.74 % in MND isolate), *T. asperellum* (58.15% in HSN isolate) and *T. harzianum* (52.96 % in RNP).The lowest per cent mycelial inhibition was recorded by *T. viridae* (40.00% in RNP and 40.37% in PYP isolate) followed by *T. asperellum* (43.70% in PYP isolate).Thus the present findings reveal that bioagents like*Bacillus subtilis*, *Pseudomonas fluorescens* and *Trichoderma viridae* are effective in reducing the fungal growth

and therefore can be used as an alternative to fungicides for the eco- friendly management of the disease, once tested under field conditions.

EP 07. Effect of organic amendments against *Sclerotium rolfsii* Sacc. causing damping off and stem rot of cowpea

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A study was conducted to check the efficacy of various organic amendments viz. Vermicompost, Coirpith compost, Neem cake, Vermiwash, Panchagavya and Fish amino acid at different concentrations both *in vitro* and under pot conditions against *Sclerotium rolfsii* in cowpea. In the laboratory test, significant control over *S. rolfsii* was observed for the treatments Vermicompost (5% conc.), Coirpith compost (15-25% conc.), Neem cake (25% conc.), Vermiwash (25% conc.), Panchagavya (15% conc.) and Fish amino acid (5% conc.). Additionally, bioagents like *Pseudomonas fluorescens* (Pf3, Pf4, and Pf5) and *Trichoderma* (Tricho A) showing antagonistic effect against *S. rolfsii* were successfully isolated from Vermicompost which indicates its increased efficiency against the disease. According to the data obtained under pot conditions, disease incidence was the least in the case of vermicompost application compared to the control with inoculum. Moreover, Vermicompost at 15% concentration showed maximum inhibition with only 8.33% disease incidence followed by 10% Vermiwash and 1% Panchagavya with 42% disease incidence. Nonetheless, all other treatments of organic amendments in varied concentrations showed more than 50% disease incidence. Although fungicides are reported to control *S. rolfsii*, the adoption of organic management over chemical control can evidently reduce the negative impact of chemicals, promoting a sustainable environment.

EP 08. Fate of gliotoxin in soil ecosystem and plants and its implication on suppressing soil-borne pathogens

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Gliotoxin, an antibiotic produced only by *Trichoderma virens*, exhibits broad spectrum antimicrobial activity against various soil-borne fungal and bacterial pathogens. However, gliotoxin production by *A. fumigatus* is considered as one of the virulence factors in causing

aspergillosis and also considered as mycotoxin. Hence, a study was aimed to decipher the fate of gliotoxin in soil and plants especially its persistence and behaviour in growth media, irrigation water, soil ecosystems and movement in plants. No gliotoxin production was noticed in neutral and alkaline growth medium. Gliotoxin was stable in acidic culture media and later converted into modified gliotoxin. In irrigation water, it was stable for several days in acidic conditions but degraded in shortly in alkaline conditions. Degradation of gliotoxin was more in unsterile soil than sterile soil and also that was higher under wet soil than dry soil. Degradation of gliotoxin was hastened by alkaline pH in wet soil but not in dry soil. Thus, gliotoxin stability is influenced by the soil wetness, soil microbial community and pH conditions. Gliotoxin movement in plants was assessed by radiolabelling technique and results will be presented. Gliotoxin producing *T. virens* suppressed the dry root rot pathogen in blackgram, gingelly and damping off pathogen in solanaceous vegetable.

EP 09. Antibiosis effect of gliotoxin producing *Trichoderma virens* for the management of dry root rot of blackgram and factors affecting stability of gliotoxin in culture medium, irrigation water and soil.

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Gliotoxin, a non-volatile secondary metabolite produced only by *T. virens*, exhibits broad spectrum antifungal activity against various soil-borne fungal pathogens. In addition, *T. virens* hyper-parasitizes the pathogenic fungi. Thus, antibiosis and hyper-parasitism together effectively suppress the pathogenic fungi. Though various *Trichoderma* spp. are commonly used for management of dry root rot of black gram, effect of gliotoxin producing *T. virens* has not been tested against the management of dry root rot of black gram so far. Hence this study was focused in evaluating the efficacy of gliotoxin producing *T. virens* on suppression of *Macrophomina* under *in vitro* and *in vivo*. The results revealed that the culture filtrates of high gliotoxin producing *T. virens* inhibited the growth of *M. phaseolina* whereas gliotoxin non-producing *Trichoderma* spp., *T. virens* did not. Gliotoxin producing *T. virens* effectively suppressed dry root rot of black gram compared to other *Trichoderma* spp. The gliotoxin was stable in acidic conditions for several days and later converted into modified gliotoxin in the culture medium. In irrigation water, it was stable for several days but degraded in one or two days in alkaline conditions. Stability of gliotoxin in soil is influenced by soil microbe, soil biota and pH.

EP 10. *In- vitro* and field evaluation of chemicals for the management of bacterial leaf stripe of arecanut

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Arecanut is one of the important plantation crop grown in Karnataka, with an area of 7,30,0000 hectares and the productivity of 1,900 kg ha-1. From past one or two decades, due to change in climatic conditions and shift in arecanut cultivation from traditional arecanut cultivation areas to non-traditional areas lead to the emergence of new diseases. Among the diseases, bacterial leaf stripe of arecanut is an emerging and serious disease that infects during the early crop growth period between 1- 6 years and its severity leads to death of the young plants. The present work was under taken to study the efficacy of different chemicals for the management of bacterial leaf stripe disease during 2019 and 2020. *In - vitro* evaluation of chemicals indicated that, Kasugamycin 5 % + Copper oxychloride 45 % showed maximum inhibition zone (29.30 mm) and was on par with Kasugamycin 5 % (27.80 mm) and differed significantly over all the other chemicals tested. Field experiment was under taken at Kunchenalli village of Shivamogga taluk. The pooled data revealed that Kasugamycin 5 % + Copper Oxychloride 45 % WP (Conica) can effectively suppress pathogen activity there by reducing the disease incidence (23.81 %), followed by Kasugamycin @ 3 ml lit-1 treated plots (26.19 %) in comparison to untreated control (57.14 %).

EP 11. GC-MS analysis of antimicrobial compounds produced by *Bacillus* spp. against Fusarium wilt of brinjal

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Brinjal (*Solanum melongena* L.) is one of the important economic vegetable crops which are attacked by several serious diseases such as wilt. The present study was conducted to develop novel microbial biocontrol agents for the effective management of Fusarium wilt of brinjal. The dominant pathogen, which causes Fusarium wilt of brinjal, was isolated and identified as *Fusarium solani* f. sp. *melongenae*. The objective of this research was to assessed their potential to control the mycelial growth of FSM. Also to identify the secondary metabolites produced by native strains of *Bacillus* sp. Fifteen native *Bacillus* sp antagonists were isolated from healthy brinjal rhizosphere soil in different geographical regions. *Bacillus cereus* strain BC7 was confirmed by 16s rRNA. Under *in vitro* conditions, the results revealed that *Bacillus cereus* isolate was found to their potential to control the mycelial growth of the pathogen by dual assay (74.39%). Furthermore, the volatile constituents were isolated from *Bacillus cereus* and subjected to gas chromatography mass spectrometry GC/MS analysis. Highest compound were identified as 1-Heptadecene, followed by 1-Nonadecene,1-Tetradecane, Dibutyl phthalate, 1-

Dodecanol. This potential indigenous *Bacillus cereus*. are widely exploited as biocontrol agents because of their efficiency in impeding various plant pathogens with multifaceted approach.

EP 12. Efficacy of native *Trichoderma* isolates in managing Fusarium wilt of tomato caused by *Fusarium oxysporum f. sp. lycopersici*

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Trichoderma being free living fungal bioagent controls many soil-borne fungal diseases with various mechanisms like competition, antibiosis, mycoparasitism. Efficacy of *Trichoderma isolates* in controlling Fusarium wilt of tomato caused by *Fusarium oxysporum f. sp. lycopersici* (FOL) was studied by pot culture method. Five native (SMV (Trichoderma *viride*), SDKd (*Trichoderma longibrachiatum)*, GMV and PSV (*Trichoderma harzianum)*, CPV (*Trichoderma asperellum*) along with one commercial isolate (*Trichoderma viride)* were used, replicated thrice. All *Trichoderma* isolates in different combinations studied include, seed treatment with *Trichoderm*a (5gkg^{-1}of seeds), seedling root dip with *Trichoderma* (during transplanting at 10gl^{-1}), *Trichoderma* enriched FYM (30g of *Trichoderma* per 1kg of FYM-20 days before transplanting), soil drenching with *Trichoderma* (15 days after transplanting @ 10gl^{-1}), foliar spray with *Trichoderma* (22 days after transplanting @ 5gl^{-1}), only FOL application (100ml per plot) (negative control), no *Trichoderma* and no FOL application (negative control). Among different treatments, T5 (combination treatment which includes seed treatment, seedling root dip, soil drenching, enriched FYM and foliar spray) recorded least average disease incidence of 20% followed by T4 (combination treatment with seed treatment, seedling root dip, soil drenching, enriched FYM) 25.55% at 60 DAT. The highest disease incidence was recorded in control with average disease incidence of 73.33% followed by T6 (seed treatment alone) with average disease incidence of 52.22%. This study confirmed that the combination treatment with isolates of different *Trichoderma* spp. inhibited the growth of the pathogen effectively. Thus, these isolates proved to be an excellent commercial exploitation prospect for biocontrol in agriculture.

EP 13. Screening of minicore collection of pigeon pea against sterility mosaic disease in northern Karnataka

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Pigeon pea minicore collection from ICRISAT were screened for the resistance against sterility mosaic disease under field conditions during *Kharif*, 2020 at College of Agriculture, Vijayapur. Out of 150 ICRISAT pigeon pea minicore accessions screened, only one accession *viz.*, ICP 15161 was found resistant against sterility mosaic disease with 10.00 per cent disease incidence and 4 accessions *viz.*, ICP 8949, ICP 11946, ICP 13579 and ICP 14903 were found moderately resistant to SMD with 25.00, 28.30, 26.75 and 20.00 per cent disease incidence, respectively. Remaining 145 accessions showed susceptible reaction to SMD with more than 30.00 per cent disease incidence. Among susceptible checks the maximum incidence of 100 per cent was observed in Maruti followed by TS-3R and Gulyal local with 94.44 and 93.75 per cent disease incidence, respectively.

EP 14. Impact of plant growth regulators in *Phytophthora Hevea* interaction

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Hevea brasiliensis, the Para rubber tree accounts for the production of 99% of the world's total natural rubber. Abnormal leaf fall (ALF) disease caused by *Phytophthora meadii* is the most devastating disease of rubber tree in India. Fungicides are commonly used to control the disease that can be highly toxic to a broad range of organisms. A new environmental friendly strategy is required to control abnormal leaf fall disease of rubber. Plant hormones were demonstrated to play preserved roles in fine-tuning immune responses. *In-vitro* effect of auxins and cytokinins on *P. meadii* mycelium growth and zoospore germination was studied. *P. meadii* were grown in Petri plates of PDA supplemented with Indole acetic acid, Naphthalene acetic acid, Kinetin and Benzyl amino purine at different concentrations of 50, 100, 250, 500, 1000, 1500 ppm. Tolerant (FX 516) and susceptible clone (RRIM 600) were pretreated with growth hormones and inoculated with *P. meadii* to check the pathogen growth and zoospore germination. Also, growth hormones were sprayed on infected leaves *in-vitro* to evaluate the disease progression. *In-vitro* effect of eight commercially available fungicides were checked to find out the minimum inhibitory concentration and a comparative analysis of growth hormone and fungicides were made. BAP was found to be effective which inhibited the mycelial

development at 100ppm. Inhibition of *P. meadii* growth by BAP provides evidence for its efficacy in developing a Nano fungicide for disease control in future. Developing a Transgenic plants expressing an increased cytokinin level could be used in future for increasing resistance in plants.

EP 15. Organic management of *Radopholus similis* infesting banana

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An experiment was conducted in farmer's field to evaluate organic practices against *R. similis* infesting banana. The fresh biomass of Glyricidia and banana was incorporated into soil after preparation of the soil or pit immediately after application in case of bio-fumigation whereas in mulching, the biomass was spread on the pit as mulch. Various treatments *viz*., mulching with green leaves of Glyricidia @ 5 kg/plant, mulching with dry leaves of Glyricidia @ 5 kg/plant, bio-fumigation with green leaves of Glyricidia @ 5 kg/plant, bio-fumigation with chopped leaves of banana @ 5 kg/plant, neem cake @ 500 g/plant including untreated control. Planting was done after 20 days of application. Though all treatments recorded less nematode population compared to control, neem cake was found most effective at 500 g/plant in recording least population of 104 nematodes/ 200 cc soil after 120 days of imposition of treatments, which was on par with bio-fumigation with green leaves of Glyricidia @ 5 kg/plant (118 nematodes / 200 cc soil). These two treatments were superior over the rest. Mulching with green leaves of Glyricidia 5 kg/plant (124 nematodes/200 cc soil) and bio-fumigation with chopped leaves of banana @ 5 kg/plant (143 nematodes/200 cc soil) were next best. Neem cake recorded highest yield of 13.87 t/ha with high ICBR of 1: 2.14 over the rest of the treatments and was significantly superior, followed by bio-fumigation with green leaves of Glyricidia @ 5 kg/plant (12.72 t/ha) and bio-fumigation with chopped leaves of banana @ 5 kg/plant (11.96 t/ha).

EP 16. Evaluation of new chemical molecules against *Meloidogyne incognita* infesting cucumber under polyhouse conditions

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New chemical molecules were evaluated against *M. incognita* infesting cucumber grown under polyhouse condition. Treatments includes Fluopyram 400 SC @ 500 g a.i./ha one Days After Transplanting (100 ml/plant) manually , Fluopyram 400SC@250g a.i./ha one DAT, again

25 DAT (2100 ml/plant) manually, Fluensulfone @ 3g /plant one DAT by ring method manually , Fluensulfone @ 1.5 g /plant one DAT, again 25 DAT by ring method manually (450 g/ha), DPX-Q8U80 500 SC @ 0.050% a.i. in 20lts one DAT (200 ml/plant) manually, DPX-Q8U80 500SC @ 0.0250% a.i. in 20lts one DAT, again 25 DAT (200ml/plant) manually, Carbofuran @ 2kg a.i./ha at transplanting including untreated check were advocated at one DAT and 25 DAT. Population of nematode was effectively managed by DPX-Q8U80 500 SC @ 0.050 % a.i. in 20 lts one DAT, again 25 DAT (200 ml/plant) manually which recorded 79.3 nematodes / 200 cc soil and 1.74 nematodes/ 5 g root followed by fluopyram 400 SC @ 250 g a.i./ha one DAT, again 25 DAT (200ml/plant) manually with 83.5 nematodes/200 cc soil and 1.96 nematodes/5 g root, fluensulfone @ 3g /plant one DAT, again 25 DAT by ring method manually recorded 87.43 nematodes/200 cc soil and 1.83 nematodea/5 g root. DPX-Q8U80 500 SC @ 0.050 % a.i. in 20 lts one DAT, again 25 DAT (200ml/plant) manually recorded Root Knot Index of 1.83, Fluensulfone @ 3g /plant one DAT, again 25 DAT by ring method manually recorded 2.01. Fluopyram 400 SC@250g a.i./ha one DAT, again 25 DAT (200ml/plant) manually recorded Root-Knot Index of 2.24.

EP 17. Biomanagement of root-knot nematode and fungal wilt complex in pomegranate

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A field experiment was conducted to manage root-knot nematode (*Meloidogyne incognita*) and fungal (*Fusarium oxysporum*) wilt complex in pomegranate with 15 treatments including bioagents *(Bacillus subtilis, Pseudomonas fluroscens, Trichoderma harzianum* and *Perpuriocelium lilacinum)* and chemicals (Cabendazim and Carbofuron) with an untreated check. With respect to nematode population in soil and root, *P. fluroscens* @ 15 g/plant + carbendazim @ 2g/l of water (drenching/ plant) performed better with RKI 1.74 followed by carbofuran 3G @ 15 g/m^2 (1.78) compared to control (4.75), while rest of the treatments recorded a range of 1.81 to 2.73. Maximum yield was recorded by *P. fluroscens* @15 g/plant + carbendazim@ 2g/l of water (drenching/ plant) and carbofuran 3G @ 15g/m^2 (948 and 953 q/ha , respectively) followed by carbendazim@ 2g/l of water (drenching/ plant) (900 q/ha) over control (473 q/ha) . Highest ICBR was recorded by *P. fluroscens* @15g/plant + carbendazim @ 2g/l of water (drenching/ plant) (2.62) followed by *Bacillus subtilis* @15g/plant + carbendazim @ 2g/l of water (drenching/ plant) (2.58), which were on par with each other and significantly different from the rest. *P. fluroscens* @15g/plant + carbendazim@ 2g/l of water (drenching/ plant) and *B. subtilis* @15g/plant + carbendazim@ 2g/l of water (drenching/ plant) also recorded maximum recovery of green leaves compared to the other treatments. *P. fluroscens* @15g/plant +

carbendazim@ 2g/l of water (drenching/ plant) was found most effective in managing *M. incognita* and *Fusarium* wilt complex in pomegranate.

EP 18. Screening and identification of source of resistance to leaf fleck disease through conventional and quantitative (q) PCR assays

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Sugarcane bacilliform virus (SCBV) causing leaf fleck disease in sugarcane, is an important DNA virus belonging to the genus *Badnavirus*, family *Caulimoviridae*. It has now been emerged as a major threat affecting global exchange of sugarcane germplasm. The sugarcane germplasm maintained at Sugarcane Breeding Institute Research Centre, Kannur under field conditions was evaluated through phenotypic and molecular assays to identify potential sources of natural resistance to leaf fleck disease. Genotypes from *Saccharam* spp. and allied genera were selected randomly and percent disease incidence and severity of selected genotypes were recorded. DNA was extracted following CTAB method and PCR assay was performed using virus specific diagnostic primers. Based on severity of symptom expression and PCR assays they were further classified as highly susceptible (HS), moderately susceptible (MS), moderately resistant (MR) and resistant (R). Among the samples 99 (66%) clones were found to be free from the disease symptoms. About 51 clones (34%) were found to be infected with SCBV. Two clones each from HS, MS, MR and R categories were assayed through quantitative (q)PCR to compare viral titre present in these clones. Cycle threshold (*C*t) values and copy numbers obtained through qPCR were compared with normal PCR assays and phenotypic symptoms. Results were similar to that of normal PCR and the highly susceptible clone D1135 recorded the lowest Ct 22.82 with highest copy number 1x 104. While Malabar which belongs to resistant category showed lowest Ct value of 34.80 with copy number 0.39.

EP 19. Transcriptomic studies reveal enigma of *Hevea - Phytophthora* interaction in tolerant and susceptible clones of rubber (*Hevea brasiliensis*)

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Transcriptional reprogramming and difference in gene expression patterns orchestrated by effectors is important in plant defense system. The present study was aimed at identifying differential expression of key genes involved in resistance mechanisms followed by identifying the major signaling pathways during *Hevea - Phytophthora* interaction as *Phytophthora* spp. causing abnormal leaf fall is the most destructive, annually recurring disease in India.

Phytophthora tolerant (FX 516) and susceptible (RRIM 600) clones were challenge inoculated with *Phytophthora* spp. and RNA sequencing was carried out. Data were analyzed to investigate difference in expression of Nucleotide Binding Sequence-Leucine Rich Repeats (NBS-LRR), a major resistance gene. Upregulation of NBS-LRR genes were more in resistant compared to susceptible clone. Expression pattern of Non-Expressor of Pathogenesis-Related (NPR1) proteins, a key regulator of SA pathway revealed upregulation in both clones under challenged condition indicating its major role during infection. Expression of the Coronatine Insensitive 1 gene (COI1) was studied in order to identify the role of JA pathway during infection as it is involved in degrading the repressor of JA responsive genes. Down regulation was detected in challenged conditions in both clones, suggesting the potential role of SA in repressing JA pathway during infection and that SA and JA defense responses are mutually antagonistic. *In vitro* leaf disc assays substantiated this concentration dependent effect of SA and JA in disease suppression. Analysis of Auxin Response Factors revealed down regulation in FX 516 and a few of those transcripts were upregulated in RRIM 600. Further work is in progress to validate these findings through qPCR analysis, which would generate a greater understanding of the difference in resistance behaviour of these clones.

EP 20. Deciphering deterrence in *Hevea brasiliensis* against *Corynespora cassicola* causing Corynespora leaf fall disease in rubber (*Hevea brasiliensis*)

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Hevea brasiliensis is the major source of natural rubber for the commercial production of latex. Corynespora leaf fall disease is one of major diseases of rubber caused by *Corynespora cassicola* leading to significant yield loss in widely cultivated clone RRII 105. Next-generation sequence based transcriptome assembly of resistant (GT 1) and susceptible (RRII 105) clones in control and challenge inoculated conditions elucidated the role of several transcripts in subduing infection of *C. cassicola*in *H. brasiliensis.* Gene transcripts of ADP/ATP binding, nuclease, kinase, glucosidase, catalase, chitinase, hydrolase, dehydrogenase and peroxidase activities were highly upregulated in GT 1 under unchallenged conditions and are related to defense responses based on gene ontology studies. Gene expression of transcripts involved in lignin biosynthesis, systemic acquired resistance, hypersenitive response and signaling molecules *viz*., salicylic acid, ethylene and jasmonic acid, in the resistant clone (GT 1) were considerably higher in comparison to the susceptible clone (RRII 105) under pathogen inoculated condition. Expression of genes encoding carbohydrate metabolic process, WRKY transcription factors, leucine rich repeat proteins, ankyrin repeats containing proteins and serine/threonine protein kinase in GT 1 clones were remarkably increased but were almost suppressed or down regulated in RRII 105 under inoculated condition, indicating significance of these genes in resistance against *C. cassicola.* Downstream analysis of recently identified differentially regulated genes would assist

in marker-based selection of resistant clones in *H. brasiliensis* thereby enhancing productivity of natural rubber as well as upholding rubber-based industries in India.

EP 21. Modern fungicidal delivery approaches to combat fruit rot disease of arecanut under field conditions

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Fruit rot of arecanut is a destructive disease caused by *Phytophthora meadii* and results in heavy economic losses to the growers. Though prophylactic sprayings of Bordeaux mixture (1%) or oomycete-specific fungicides are useful in reducing the disease, managing this disease under field conditions is of great challenge due to difficulty in climbing the trees during the monsoon for timely spraying. The present study was aimed at evaluating some of the new fungicides through spraying from ground level and by a new approach of soil application of fungicide-loaded "briquettes". Spraying of fungicides namely Bordeaux mixture (1%), mandipropamid (0.5%), fosetyl-Al (0.3%) and combination of metalaxyl-mancozeb (0.2%) through the spraying from ground just before the onset of monsoon during the last week of May followed by spray after 40 days of the first spray reduced the fruit rot severity up to 65-70 % and increased the dry nut yield by 75-95% compared to untreated control. Whereas, soil application of "fertilizer briquettes" (100g /palm) amended with fosetyl-AL, fosetyl-Al-propineb and urea to the root zone of arecanut thrice at 30-45 days interval reduced the fruit rot severity by 70% and increased dry nut yield by 100% compared to untreated control. Analysis of two years of disease severity data and benefit-cost ratio (B:C) demonstrated that soil application of fungicide amended "fertilizer briquettes" is an alternative to arduous conventional spraying for management of fruit rot disease in arecanut. This is the first report on the use of fungicide amended 'Fertilizer Briquettes" for management of any plant disease.

EP 22. Management of chilli fruit rot caused by *Colletotrichum capsici*

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Chilli, *Capsicum annum* L. is an annual herbaceous vegetable as well as spice crop grown in both tropical and subtropical regions belonging to the Solanaceae family. Its production is

threatened either by many fungal diseases. Among fungal diseases anthracnose caused by *Colletotrichum capsici* is a major constraint in chilli production leading to huge economic losses in the country, because, as it is the main constrictive factor in both pre and postharvest stages. In the present study, an attempt was made to evaluate fungicides against *C. capsici in vitro* and in the field conditions at, UHS Bagalkot, Karnataka during the year 2019.Results revealed that, among the fourteen different fungicides tested under *in vitro*, a combi product fungicide fluxapyroxad + pyraclostrobin showed cent percent inhibition at all the tested concentration. Among four contact fungicides, captan at 2000 ppm showed cent percent inhibition. Among seven systemic fungicides *viz.*, tebuconazole, difenconazole and propiconazole were found effective, which has shown cent percent inhibition of mycelial growth in all tested concentrations. Field management study was carried out during *kharif* 2019at HREC, Haveri with varietyByadagiDabbiTotally ten different fungicides and one bioagent (*Pseudomonas fluorescens*) were sprayed with 3 replications. Among eleven treatments 0.05% fluxapyroxad + pyraclostrobin, 0.1% propiconazole were found most effective in reducing fruit rot (PDRC 65%) and increasing fruit yield (14.83 and 14.31 q/ha) with highest B:C of 3.47 and 3.41 respectively followed by 0.1% of propiconazole, hexaconazole, difenconazole and tebuconazole were remain on par with each other. Carbendazim + Mancozeb was least effective in reducing fruit anthracnose (16%) and yield (8.4 Q/ha) with B:C of 2.0.

EP 23. Biocontrol potential of native *Trichoderma* spp. against anthracnose/twister disease of onion

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Onion (*Allium cepa* L.) called as "queen of kitchen" is one of the oldest known and an important vegetable crop grown in India. Several factors have been identified for the low productivity of onion in India. The most important factors responsible are the diseases like purple blotch, *Stemphylium* blight and twister disease. In the recent years, twister disease has become epidemic on onion crop causing to the tune of 80-100% yield loss by *Colletotrichum gloeosporioides*. Anthracnose causing significant economic and production losses, are becoming a serious threat to global food security. Due to an increase in fungal resistance and the hazardous effects of chemical fungicides to human and environmental health, scientists are now engaged to explore alternate non-chemical and eco-friendly management strategies. The use of biocontrol agents is one of the potential approaches used today. *Trichoderma* spp. are well known biocontrol agents used globally. During *kharif* 2021 a field trial was conducted on onion variety Bhima super to test the efficacy of thirteen different *Trichoderma* spp. against anthracnose/ twister disease of onion under field condition at ICAR-DOGR, Pune. The study revealed that, all the tested *Trichoderma* spp. performed well in promoting the growth parameters (4 to 8% leaf

diameter, 6-27% pseudostem girth and 9-19% number of leaves), 7 to 54% reduction in the disease incidence and enhancement in bulb yield from 6 to 48%. By looking into the all attributes the treatments *Trichoderma* T-4 R and *Trichoderma harzianum* were found promising in managing the disease followed by *Trichoderma*-NRCGT-8 and *Trichoderma asperellum*. Due to the influence of *Trichoderma spp.* on vigorous physiological growth of plants as well as efficacy not only managed the anthracnose but also reduced the other fungal disease incidence *viz.*, purple blotch, *Stemphylium* blight and basal rot disease.

EP 24. Coffee anthracnose disease and recent management approaches in India

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Coffee anthracnose disease caused by *Colletotrichum gloeosporioides* is widely distributed in almost all coffee growing countries in the world with variable symptomatic characteristics and disease severity. In India, coffee anthracnose has three important symptoms *viz.*, twig die-back, the brown blight of leaves and stalk rot of berries. Twig die-back is commonly noticed during the dry weather after cessation of monsoon. The typical symptoms start with yellowing and blighting of leaves, necrosis of nodes and internodes running upwards towards the tip, and as the disease progresses gradually leading to the defoliation with die-back appearance. Infected leaves appear as small irregular necrotic brown colour blighted lesions initially and later develop yellowing through leaf veins and midrib which leads to defoliation and the fruiting bodies of the pathogen were also noticed on the necrotic spots. The stalk rot symptoms occur during the monsoon period when soil moisture and atmospheric humidity reaches near to saturation. Infected stalk tissues of the berries disintegrate and later turns to brownish black colour which in turn leads to pre-mature fruit drop and the stalk remains on the branches resulting in the reduction of yield and also affecting the coffee quality. To minimise the crop loss due to anthracnose disease afield experiment was carried out for two consecutive years from 2020-21 and 2021-22 to evaluate the bio-efficacy of fungicides at Central Coffee Research Institute, Chikkamagaluru District, Karnataka with plant material Robusta (CxR). Pre-monsoon spray of five fungicides *viz.*, carbendazim 50 WP @ 1 g/L, propiconazole 25 EC @ 1 ml/L, tebuconazole 25 EC @ 1 ml/L, trifloxystrobin 25% + tebuconazole 50% WG @ 1 g/L and Bordeaux mixture 1%. Results on stalk rot disease incidence during 2020-21 indicated nil incidence in treatment trifloxystrobin 25% + tebuconazole 50% @ 1 g/L whereas least (2.06%) incidence in tebuconazole 25 EC @ 1 ml/L followed by propiconazole 25 EC @ 1 ml/L (4.31%), carbendazim 50 WP @ 1 g/L (10.00%) and 1% Bordeaux mixture (24.10%). Untreated control recorded 46.18% incidence. Data during 2021-22 indicated that least (1.2%) incidence in treatment trifloxystrobin 25% + tebuconazole 50% @ 1 g/L followed by tebuconazole 25 EC @ 1 ml/L (1.90%), propiconazole 25 EC @ 1 ml/L (3.80%), carbendazim

50 WP @ 1 g/L (6.12%) and 1% Bordeaux mixture (6.12%). Untreated control recorded 14.25% disease incidence. Present study has stated that an alternative fungicide may be used for effective management of coffee anthracnose disease.

EP 25. Management of cotton leaf spot pathogens, *Alternaria alternata* and *Paramyrothecium roridum* using botanicals

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Cotton is being infected by several fungal pathogens causing leaf spot disease. In Tamil Nadu, two major fungal leaf spots pathogens *Alternaria alternata* and *Paramyrothecium roridum* incidence were observed. Different botanicals were tested against these two diseases in this investigation. Six plant leaf extracts: Datura, Henna, Notchi, Thulasi, Thuthi and Sweet flag; four organic amendments: Gingelly cake, Groundnut cake, Mustard cake and Neem cake and four essential oils: Eucalyptus, Lemongrass, Neem and Thyme oils, each at 5% were screened *in vitro* against *Alternaria alternata* and *Paramyrothecium roridum* by poison food technique. Thulasi leaf extract, Gingelly cake extract, and Lemongrass oil were the most effective botanicals in controlling the leaf spot pathogens, with percent reductions of 15.7%, 84.3%, and 100% for *A. alternata* and 16.9%, 71.4%, and 100% for *P. roridum*, respectively.These three botanicals were then evaluated individually and in combination in a glasshouse condition along with a fungicide check (Tebuconazole 50% + Trifloxystrobin 25%). The disease incidence was reduced with a per cent disease index of about 25 when Gingelly cake extract was applied alone. The next better management combines gingelly leaf extract andthulasi leaf extractwith a per cent disease index of about 27.5. When all three of these treatments were used together, the disease management was poor.

EP 26. Salicylic acid induced systemic acquired resistance against *Chilli Leaf Curl Virus* (ChiLCV) in *Capsicum annum* L.

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Capsicum, an important solanaceous vegetable and condiment crop of India which plays an important role in Indian economy is affected by many viruses. *Chilli leaf curl virus* (ChiLCV) is the most destructive virus effecting *Capsicum* growth and yield in India, with symptoms of abaxial curling of leaves accompanied by puckering, thickening and swelling of the veins; transmitted by whitefly. It belongs to *Begomovirus* genus having ssDNA genome. Unlike other plant pathogens, plant viruses are nearly impossible to control, instead practical attempts are made to keep them in check and to reduce yield losses. Most practical and economically viable method for protecting plants against pathogen is resistance. Induction of plant resistance by systemic acquired resistance (SAR) is a possible and/or complementary alternative to manage virus infections in crops. The present work investigated plant defence response using Salicylic acid (SA) foliar spray against ChiLCV. Salicylic acid foliar sprays application showed significant differences in percentage of inhibition on *Capsicum* plants compared with control application. It also delays the onset of infection and reduces the disease severity with increased growth and yields compared to control. It upregulated the defense-related genes and internal SA accumulation, a key factor for SAR. Based on the results of this work and earlier reports, it is suggested that SA induces systemic acquired resistance against ChiLCV via activating multiple plant defense signaling pathways. Hence, can be considered as a potential activator for inducing plant resistance.

EP 27. Effectiveness of fungicides on the management of sooty mould (*Capnodium* sp.) in cotton

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A study was taken up to manage *Capnodium* sp which causes sooty mould diseases in many field and horticultural crops, and responsible for considerable yield loss. Experiment was laid out with four chemicals namely copper oxy chloride, propiconazole, mancozeb and detergent powder in different concentrations and their effectiveness in managing sooty mould was studied. Initially, a pot culture experiment was conducted. The effective treatments from the

pot culture experiment were taken to the field experiments. The final yield and disease incidence were recorded. The lowest incidence (2.66) of sooty mould was recorded when propiconazole 25EC @ 1ml/litre of water was applied, yielding 11.9 q/ha. Next best effective treatment was copper oxy chloride 50 WP @ 2.25 g/litre of water, with a yield of 11.0 q/ha. The sooty mould was not controlled effectively when mancozeb 50 WP @ 2.0g / litre of water was applied where the yield was 9.0 q/ha, which is the least of all.

EP 28. Bio-efficacy of new fungicide molecules against coffee leaf rust pathogen *Hemileia vastatrix*

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Coffee is an economically important plantation crop in many countries which is main source of income for more than 100 million people around the world. Coffee Leaf Rust (CLR) is devastating disease of coffee caused by the fungus *Hemileia vastatrix*. Among two commercially exploited species of coffee, *Coffea arabica* is highly susceptible to CLR and leads to immense yield loss if proper disease management practices are not followed. To identify an alternative to existing recommended fungicide, new fungicide molecules, picoxystrobin 7.05% + propiconazole 11.71% SC and picoxystrobin 6.78% + tricyclazole 20.33% SC were evaluated against leaf rust pathogen by spore germination studies. The fungicides were tested at 100, 250, 500, 1000 and 2000 ppm in comparison with recommended fungicides hexaconazole 5 EC @ 2000 ppm and alkaline Bordeaux mixture @ 0.5% in a CRD design with three replications. Untreated control was also maintained. Results indicated that, among the treatments, fungicides picoxystrobin 7.05% + propiconazole 11.71% SC and picoxystrobin 6.78% + tricyclazole 20.33% SC @ 1000 ppm & 2000 ppm and the recommended systemic fungicide hexaconazole @ 2000 ppm were highly effective and recorded nil uredospore germination. Minimum (1.02%) uredospore germination was observed in picoxystrobin 7.05% + propiconazole 11.71% SC @ 500 ppm and on par with picoxystrobin 6.78% + tricyclazole 20.33% SC @ 500 ppm (1.74%). Alkaline Bordeaux mixture @ 0.5% recorded germination of 2.45%. Whereas, maximum uredospore germination (27.47%) was recorded in picoxystrobin 7.05% + propiconazole 11.71% SC @ 100 ppm and untreated control recorded 91.73%. Further, effective fungicides can be evaluated under field conditions for the management of coffee leaf rust.

EP 29. Large scale demonstration on the use of *Trichoderma* bio-fungicide for management of chilli wilt

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Chilli is the most cultivated commercial spice and vegetable crop in North Karnataka, its successful cultivation depends upon efficient management of pests and disease. Among the diseases, chilli wilt caused by *Fusarium oxysporum* is the most serious and threatening disease in its cultivation. The disease has been recurrent in many chilli fields across more than 12 talukas of Kalaburagi, Raichur, Yadgir, and Vijayapur districts. Though farmers have been trying chemical management options such as spraying and drenching with chemical fungicides but could not curtail the disease. The disease was spreading very fast across the plots post rainy seasons, especially during the fruiting and maturity stage. Thus, many farmers were under stress and threatened of losing the crop. To mitigate the sudden outbreak of chilli wilt, the drenching of *Trichoderma* bio-fungicide was undertaken in 68 plots ranging from flowering to fruit ripening stage with wilt ranging from 8 to 52 per cent. *Trichoderma* drenching @ 5 g/lit was advocated on pre irrigated wet plots to ensure the solution reach rhizosphere of the plants. Drenching was done using battery-operated and hand-operated knapsack sprayers without nozzles for free flow of solution. Each acre was provided with 400 to 500 liter of drench solution. The drenching was repeated once again after 15 days. Rhizosphere application of bio-fungicide could arrest the further wilting and boost good crop health. This practice prevented future damage and destruction of crops especially at maturity which otherwise would have been the loss of money, time, efforts, and resources. This not only halted the death of plants but also provided safe and secured harvesting of fruits till the last picking. Farmers were convinced of this practice so much so that all the 68 plots on 240 acres were covered totally with their own cost without any free distributions. The major observation and feedback received is, quality and timely availability of bio-inputs at an affordable price is the key for their successful adoption. *Trichoderma* has a promising role in controlling many soil borne pathogens including wilt and its application should be encouraged in vegetables that are more prone to diseases.

EP 30. Bio-efficacy of propiconazole 13.9% + difenoconazole 13.9% EC against *Myrothecium roridum* in coffee

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Myrothecium roridum is known to infect leaves and stem of coffee seedlings in the nursery as well as leaves and berries in coffee plantations. Severity of the *M. roridum* infection is always associated with high rainfall during monsoon period and causes huge loss of seedlings in the nursery. Considering the importance of the disease, *in-vitro* evaluation of new fungicide i.e., propiconazole 13.9%+ difenoconazole 13.9% EC was carried out at different concentrations *viz.*, 0.10ml/L, 0.25ml/L, 0.50ml/L, 0.75ml/L& 1.00 ml/L along with difenoconazole 25% EC alone @ 0.50ml/L& 1.00 ml/L and propiconazole 25% EC@1.00ml/L as a recommended standard check. The experiment was conducted by following poison food technique. The observations were recorded at 30days after incubation revealed that all the concentration of the test fungicide propiconazole 13.9%+ difenoconazole 13.9% EC was found to be on-par with recommended standard check i.e., propiconazole 25% EC@1.00ml/L with respect to percent mycelial inhibition. Interestingly, difference was observed with respect to sporulation of *M. roridum in* different fungicidal treatments. Among the treatments no sporulation in propiconazole 13.9%+ difenoconazole 13.9% EC @ 0.50ml/L, 0.75ml/L& 1.00 ml/L; low sporulation in propiconazole 13.9%+ difenoconazole 13.9% EC @ 0.25ml/L & recommended standard check propiconazole 25% EC@1.00ml/L; medium sporulation in propiconazole 13.9%+ difenoconazole 13.9% EC@ 0.10ml/L and high sporulation in difenoconazole 25% EC@0.50ml/L, 1ml/L as well as untreated control. Further, the effective concertation of the fungicide propiconazole 13.9%+ difenoconazole 13.9% EC will be tested against the pathogen in nursery as well as in field conditions.

EP 31. Influence of plant nutrients on sheath blight severity in different rice genotypes

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Rice sheath blight is one of the world's most economically important rice diseases. This disease has a substantial impact on grain yield and quality. Owing to lack of resistant cultivars, fungicides and cultural methods are necessary in the treatment of sheath blight. Mineral nutrition has been used as a supplement in the treatment of diseases since plant nutrients are required for both plant and pathogen growth and metabolism. Here, an effort was made to reveal the effect of plant nutrients on sheath blight severity in different rice genotypes. Correlation and regression results revealed that among the ten plant nutrients, nitrogen (0.88) and phosphorous (0.77) were found to have significant positive correlations and were responsible for 79% and 59% of the increase in sheath blight disease, respectively, whereas magnesium (0.21), iron (0.25) and zinc (0.012) were also found to positively influence the disease with 4.5%, 6.2% and 0.14% increases in disease severity, respectively. But a significant negative correlation was observed in potassium (-0.50) and calcium (-0.4) with 25.0% and 15.9% increases in disease severity, respectively. Whereas, sulphur (-0.02), copper (-0.15) and manganese (-0.26) influence 0.5%, 2.3% and 6.8% increases in severity, respectively. The study also showed the effect of nutrient ratios on sheath blight severity and found that infected genotypes had greater N: S, N: P and P: S ratios than healthy genotypes. However, the infected genotypes had lower K: S, N: K and P: K than the healthy genotypes.

EP 32. Exploitation of secondary metabolites from endophytic *Trichoderma asperellum* against *Rhizoctonia solani* infecting tomato

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Studies on exploitation of secondary metabolites from fungal endophyte against soil-borne fungal pathogen *Rhizoctonia solani* infecting tomato was conducted in *in-vitro* condition during the year 2020-21. Fungal endophytic Operational Taxonomic Unit (OTU) *Trichoderma* sp. isolated from root tissues of *Parthenium hysterophorus*, was evaluated against *Rhizoctonia* sp. infecting tomato by dual culture technique as a preliminary screening. Internal Transcribed Spacer (ITS) region, smaller and larger ribosomal subunit region sequencing and analysis of *Rhizoctonia* sp infecting tomato and endophytic *Trichoderma* sp. revealed that, the pathogen as *Rhizoctonia solani* and endophyte as *Trichoderma asperellum*. To exploit the secondary metabolites as a potential source from endophytic *T. asperellum* against *R. solani*, extraction of secondary metabolites from *T. asperellum* followed by disc diffusion assay and double Petri dish assay was conducted where, both the assays showed positive inhibitory action against *R. solani*. Further, secondary metabolites extracted from *T. asperellum* was processed for metabolite profiling through liquid chromatography-electrospray ionization-mass spectrometry (LC-ESI-MS/MS) and gas chromatography-mass spectrometry (GC-MS) analysis for characterization of diffusible and volatile organic compounds, respectively. LC-ESI-MS/MS analysis showed the presence of antimicrobial diffusible compounds (three compounds) compounds, and GC-MS analysis showed the presence of antimicrobial volatile organic compounds(eight compounds) produced by endophytic *T. asperellum*. Further, scanning electron microscopic studies showed the parasitizing behaviour of *T. asperellum* on mycelium of *R. solani* which revealed the hyperparasitic nature of endophytic *T. asperellum.*

EP 33. *In vitro* evaluation of systematic fungicide against powdery mildew pathogen of sandal

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Sandal (*Santalum album* L.) a commercially valued medicinal tree species belongs to the family Santalaceae. High value of its heart wood oil and liberalization promoting Sandal area expansion in diverse geographical regions. Healthy seedling production and supply has vital role. Nursery seedlings

hampered growth and mortality was at faster rate by diseases. Powdery mildew appeared as major in the disease survey in different agroclimatic zones of Karnataka. Powdery mildew conidial germination inhibition at two concentrations each of twelve different systematic fungicides was done by spore germination method using cavity slides. The highest conidial germination inhibition was by 300 ppm of hexaconazole 5% SC (51.48%) followed by propiconazole 25% EC (300 ppm) (46.33%). Least conidial germination inhibition was by 100 ppm of azoxystrobin 23% EC (20.12%) followed by 100 ppm of tebuconazole 25 % EC (25.74%). Maximum mean per cent inhibition was in hexaconazole 5% SC (46.41%) followed by propiconazole 25% EC (42.35%) and minimum inhibition per cent was recorded by azoxystrobin 23% EC (25.89 %).

EP 34. Testing the efficacy of native isolates of *Trichoderma* sp. against rusts and head scab pathogens of wheat

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Wheat (*Triticum aestivum* L.) is the important cereal and stable food crop in India. Rust diseases and Fusarium head blight (FHB) or scab of wheat, are of the most important diseases in this crop. Both diseases cause significant yield and quality losses in wheat grains. Premature bleaching of spikelets is the typical symptoms of head scab disease of wheat which affects quality of grains. The infected grains are undesirable for consumption owing to elaboration of different toxic metabolites. Considering the environmental safety and recent changes in pesticides regulations in banning of important fungicides, as an alternate strategy, we investigated the efficacy of native isolates of *Trichoderma* sp., against stem rust (*Puccinia graminis* f.sp. *tritici- Pgt),* leaf rust (*Puccinia triticina- Ptr)* and head scab (*Fusarium graminearum*) pathogens of wheat. The soil (rhizosphere region) and leaf samples of wheat were collected from different fields at Niligiri (Southern Hill Zone of India). From the samples, two isolates of *Trichoderma* sp., one from rhizosphere region and another from phyllosphere region have been isolated and purified. Since *Trichoderma* species is an effective bio protector with broad spectrum activity used for the management plant diseases, these were tested for their antagonistic activity against *F. graminearum* by dual culture technique. It was found that both the isolates inhibited the mycelial growth of *F. graminearum*. An isolate from phylloshere region parasitized on mycelia of head scab pathogen. The culture filtrate of *Trichoderma* sp. grown on PD broth was tested for its antagonistic effect against both the rust pathogens. However, inhibition efficacy was different between these two and the results revealed that more than 95% inhibition of spore germination of leaf/ brown rust of wheat whereas, only 40 % inhibition was recorded against stem rust when compared to control. However, the germ tube elongation was reduced in case of stem rust urediospores as compared to control. These results revealed that the native isolate of *Trichoderma* sp., is effective and having direct inhibitory effect on germination of brown rust (*Ptr*) but not having direct effect on germination of stem rust (*Pgt*) spores of

wheat. Further works are in progress to augment this native isolate of fungal bioagent for the management of both head scab and rusts of wheat.

EP.35 Induced Systemic Resistance in Chilli against *Colletotrichum capsici*

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Chilli, an important ingredient in Indian cuisine, is a major commercial commodity farmed in tropical and subtropical locations, with India being the world's leader in chilli production. Chilli is affected by several diseases viz., powdery mildew, fungal, bacterial wilt, leaf curl, etc. out of which the anthracnose of chilli is the most devastating disease, it is also termed as dieback or fruit rot caused by Colletotrichum capsici. The disease causes substantial damage in the field, as well as during storage and transit, exacerbating yield and overall crop production losses. Anthracnose disease has been observed to cause a 10–54 percent yield reduction in India. Because this disease is so common, scientists are using integrated management approaches such as physical, mechanical, biological, and chemical. However, management exercises performed after the disease has occurred have not proven to be effective or cost-effective. As a result, an approach that strengthens the plant from a very early stage is required and reliable, so induced resistance is proposed and discussed. Systemic acquired resistance (SAR) and induced systemic resistance (ISR) are two forms of induced resistance wherein plant defenses are preconditioned by prior infection or treatment that results in resistance against subsequent challenges by a pathogen or parasite. This paper focuses on having discussion about the concept becoming increasingly important which enables and empowers the plant system to tackle the target pathogen(s) using its own defense mechanism.

EP.36 Induced resistance in Brinjal against Phomopsis blight

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Phomopsis blight caused by Phomopsis vexans has been a devastating disease that affects the production of brinjal by 40–70% and makes brinjal fruits unmarketable and inedible, limiting their role in income generation, nutrition, and health. Cultural, mechanical, biological, and chemical methods have been discussed and used extensively in previous researches. Though the chemical methods for the management were found most effective and accepted worldwide by the grower, it has many negative consequences to humans, environment, soil, water, and plant bodies. Heavy use of fungicides also results in developing resistance to plant pathogens. So, there is a strong need of one environmentally friendly and healthy approach which allows a plant to develop resistance. This concept of developing resistance into the plant system is termed as

induced resistance, one of the induced resistances is systemic acquired resistance works on the principle of the salicylic acid pathway while induced systemic resistance works on the principle of the jasmonic acid pathway. This manuscript gives a review, why Phomopsis blight is an economically important disease of brinjal and gives an extensive discussion on sustainable management strategies in comparison to the conventionally recommended control for the disease.

EP.37 Rapid Method on Identification of Resistant Genotypes Against Powdery Mildew Pathogen (*Blumeriagraminis*f.sp*tritici*) of Wheat

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Wheat is the second major cereal crop for the food and nutritional security of Indian people. It is mainly infected by many biotrophicfungal pathogens. Rusts and powdery mildew are the most devastating diseases in this crop. Powdery mildew caused by *Blumeriagraminis*f.sp*tritici* is becoming major disease for wheat cultivation in India. Both qualitative and quantitative loss in grains could be observed when test pathogen infects ear heads under field conditions. Powdery mildew alone can cause more than 50% yield loss worldwide in every year and in our country it was reported up to 30% yield loss. The air borne asexual conidia spread very fast in healthy crops and affect the efficiency on photosynthesis of infected leaves. Identification of resistant sources in difficult for powdery mildew disease but we attempted to profile the reaction pattern of a set of defined wheat lines screened out over the period. In our study, 367 lines marked in different periods of evaluations were used for profiling the reaction pattern. We followed two methods ie., seedling resistant test (SRT) under controlled conditions and adult plant reaction (APR) in open field conditions, in which the first one was standardized in our station. Wheat powdery mildew conidia were multiplied on surface sterilized seedlings of a susceptible cultivar (WL 711) and contaminant free spores were artificially inoculated by following our Sandwich method of inoculations. One set of conidia were purified on susceptible cultivar and used for confirming its identity using light microscopy and DNA sequences. Genomic DNA was isolated by following CTAB method, 50ng of template DNA added with ITS primer was amplified and the purified PCR product was sequenced. After confirming the phenotypic and genetic identity of*Bgt* pathogen, all 367 lines were inoculated and incubated in a specially designed polyhouse with controlled conditions. Same set of lines were grown in open field conditions by following the standard agronomical practices. Both seedlings and adult plants were evaluated based on 0-9 scale on mildew symptoms and severity. Analysis of data from seedling reactions resulted that out of 367 lines of wheat cultivars, 23lines revealed completely free or immune response and 97 lines expressed susceptible reaction under controlled conditions (SRT).A total number of 91(24.79%) lines and 138 (37.60%) lines were expressed moderate/intermediate resistant reaction and intermediate susceptible reaction respectively. However, under field screening, out of these total lines, almost 45.23% (166 lines)expressed

complete/ immune response and only 6 lines were under susceptible category. A total number of 108 lines (29.42%) and 14 lines (3.8%) were expressed moderate/intermediate resistant reaction and intermediate susceptible reaction respectively. Out of these, 4.3%(16 lines) expressed consistency in their resistant reaction pattern and 13 lines were expressed reliability in their susceptible reaction pattern for SRT with APR.Since the field screening may be taking more than 80-90 days as compared to 20-30days in SRTmethod.Moreover, this method is resources intensive, free from other contaminants, rapid for testing large number of genotypes and discrepancies due to disease escape could overcome. Therefore, theseadvantages could be explored than field screening for getting accurate reaction pattern against a particular pathotype or races of *Bgt* without any contaminants. It is summarized from present results that a large number ofwheat genotypes can be screened out and durable resistant sources could be identified in short span of time.

PROF. M. J. NARASIMHAN ACADEMIC MERIT AWARD CONTEST

Chairman	:	Dr. Selvarajan, R., Principal Scientist, ICAR-NRCB
Co-chair	:	Dr. Vinayaka Hegde, Principal Scientist, ICAR-CPCRI
Convener	:	Dr. Daliyamol, Scientist, ICAR-CPCRI

MJN 01. Epidemiology and management of powdery mildew of okra caused by *Erysiphe cichoracearum*

Ashwini, R. and Amaresh, Y. S.*
*Major advisor

Okra powdery mildew caused by *Erysiphe cichoracearum* DC. is a destructive disease causing potential yield loss. Survey conducted during *Rabi* 2019-20 and *Rabi* 2020-21, revealed that, mean disease severity was maximum in Ballari (60.59, 56.00 %) and least in Yadgir (40.81, 37.18 %) districts. Out of 17 crop plants tested, powdery mildew symptoms were developed on five cultivated crops *viz*., cucumber, ridge gourd, black gram, green gram, cowpea. Spore germination of *E. cichoracearum* was maximum in 1.5 per cent glucose solution (84.64 %) at 24 hours of incubation. Highest conidial germination (58.12 %) was observed at 25 ^{0}C and (56.32 %) at 85 per cent relative humidity. The correlation study revealed that, during *Rabi* 2019-20, maximum 'r' value (0.157) was recorded one week after initial infection and maximum (528.15) AUDPC value recorded on 49th SMW. Whereas, during *Rabi* 2020-21, maximum 'r' value (0.155) was recorded at two weeks after initial infection and maximum AUDPC value (514.50) recorded on 49th SMW. The auto regression studies lead to equation for *Rabi* 2019-20, Y = 7.9 + 0.86X with R = 0.91 while *Rabi* 2020-21 Y = 7.579 + 0.849X with R = 0.902. Out of 50 genotypes screened, one genotype *i.e*., EC329404 showed moderately resistance reaction. Comparatively low disease index (9.08 %) with increased yield (96.59 q ha^{-1}) recorded in plots received with three sprays of difenconazole (0.1 %).

In *in vitro* evaluation, among the systemic fungicides, difenconazole (86.06 %), among the contact fungicides, wettable sulphur (78.68 %), among the combi fungicides, tebuconazole 50 % + trifloxystrobin 25 % (88.06 %) resulted in maximum inhibition (88.06 %). Among bio agents evaluated, mean maximum inhibition observed with *P. fluorescence* (Pf-1) (64.20 %). Field evaluation of fungicides during *Rabi* 2019-20 and *Rabi* 2020-21 revealed that, three sprays of tebuconazole 50% + trifloxystrobin 25% recorded maximum disease reduction of 91.81, 89.91 per cent over untreated control and yield up to 110.54, 108.18 q ha^{-1}.

MJN 02. Exploring plants and microbes associated volatilomes against damping off caused by *Pythium aphanidermatum* in tomato

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Soil borne diseases are the major threat for many vegetable crops, especially in tomato cultivating areas. Damping off caused by *Pythium aphanidermatum* was known to cause severe

crop losses. The volatilomes from several plants and microbial origin could produce novel volatile organic compounds (VOCs), which may have a great extent for exploration as antifungal agents against the plant pathogens. The volatilomes produced by the leaves of *Mentha spicata*, *Cymbopogon citratus*, *Vitex negundo*, *Coleus amboinicus*, *Vetiveri azizanioides*, *Ocimum tuniflorum*, *Azadirachta indica*; mycelia of *Auricularia auriculata*, *Coprinus cinereus*, *Ganoderma lucidum*, *Lentinus edodus*, *Trichoderma asperellum* and cell cultures of *Bacillus subtilis*, *Streptomyces rochei* were screened for their antifungal activities against *P. aphanidermatum* by sealed plate assay. Among them, the volatilomes produced by the leaves of *M. spicata* and *C. citratus* showed the maximum inhibitory effect of 45.56 and 24.70 per cent, respectively on the mycelial growth of *P. aphanidermatum.* The volatilomes produced by the mycelia of *T. asperellum* showed the maximum inhibitory effect of 69.26 per cent against *P. aphanidermatum.* In order to identify the nature of VOCs involved in the suppression of pathogens, carvone produced by the leaves of *M. spicata*; citronellol and geraniol by *C. citratus*;isopentyl alcohol and limonene by *T. asperellum*with increased peak area percentage. Vaporous action of isopentyl alcohol completely suppressed the mycelial growth of *P. aphanidermatum*, while the compounds, carvone and citronellol showed the maximum inhibitory effect of 89.02 and 85.49 per cent, respectively when used at 500 ppm. The volatilomes produced by the leaves of *M. spicata, C. citratus* and mycelial cultures of *T. asperellum* were immobilized in vermiculite sample bound with castor oil in the ratio of 3:7 as the volatilomes immobilized vermiculite ball formulation and their efficacy were tested *in vitro* by olfactory chamber. The results revealed the volatilomes of *M. spicata* immobilized vermiculite balls could completely suppress the mycelial growth of *P. aphanidermatum*. Futher, the volatilomes formulation were tested based on the distance travelled by the diffused volatilomes using PVC chamber. The results revealed that the volatilomes of *M. spicata* travelled up to 20 cm distance from the centre of PVC chamber showed maximum reduction of colony growth of *P. aphanidermatum* (2×10^{-3}cfu) at 12^{th} day after inoculation.

Studies on the management of damping off in the volatile chamber under glass house conditions revealed that the volatilomes of *M. spicata* immobilized vermiculite balls significantly reduced the severity of damping off (with a per cent reduction of 90.91).

Studies on defense genes expression revealed that pathogenesis related protein (PR1) (2.69 folds) and jasmonic acid signaling (LOX) (2.65 folds) genes were highly expressed after 48 hon exposure to the volatilomes of *M. spicata* immobilized vermiculite balls against *P. aphanidermatum* in tomato plants.

MJN 03. Identification, multi-genic and teleomorphic characterization of *Bipolaris setariae* causing browntop millet leaf blight in India

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Browntop millet (*Brachiaria ramose* (L.) Stapf.) is one of important climate resilient crop and it was recently introduced into millet system in India. In *Kharif* 2018, leaf blight was first time observed at ICAR-AICRP germplasm evaluation trails atBangalore. Initially, spots were brown with yellow halo eventually turns todark brown and leaves were blighted. Disease was observed to be maximum in southern Karnataka. Pathogen was isolated and pure cultured using standard isolation and single spore isolation techniques. Likewise, nine isolates were recovered on Potato Dextrose Agar medium from major millet growing regions of India and all isolates were found pathogenic on brown top millet in pathogenicity studies. Morphologically, the pathogen was identified as *Bipolaris* spp. by comparing with standard descriptions. Further, BLAST and combined phylogenetic analysis of ITS, GPDH and LSU regions revealed that *Bipolaris setariae* as the causal organism of brown top millet leaf blight in India. $BTMH_5$ isolate was identified as more virulent among all. In vegetative compatibility studies, $BTMH_2 \times BTMH_6$ showed compatible reaction where H-shaped hyphal anastomosis was observed. Barren pseudothecia are produced on Sach's agar medium. Amongst the 40 germplasm screened only six were found moderately resistant and none of the showed resistant reaction.

MJN 04. *Bacillus* spp. a powerful tool in managing rhizome rot of banana caused by *Pectobacterium caratovorum* subsp. *caratovoroum*

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Banana isone of the important fruit crops of tropical and subtropical regions of the world. Among the diseases threatening banana cultivation, rhizome rot caused by *Pectobacterium caratovorum* subsp. c*aratovoroum*(*Pcc*) is causing much damage to the crop**.**During a recent survey disease incidence of 45% was recorded. Biological control is one of the viable mode of managing the disease.A total of 270 endophytic and 130 rhizospheric bacteria of banana were isolated on laboratory medium and screened against *Pcc* for their antibacterial activity*in vitro* and the best two isolates EL2 and LgS5 were further tested in glasshouse and in orchard for rhizome rot disease suppression. These two isolates were identified as *Bacillus aereus* and *Bacillus safensis* based on sequence similarity and phylogenetic analysis of 16S rRNA region and they were tested for their mechanism of antagonism and found that both the isolates had shown a zone of inhibition of 15 mm in *in vitro* assay using culture filtrates. The compounds which are expected to be involved in inhibiting *Pcc* were identified tentatively by LCHRMS analysis. Both the isolates were positive for siderophore production, *Bacillus aereus* EL2, was positive for HCN and negative for NH_3 production. *Bacillus safensis* LgS5 was positive for NH_3 and negative for HCN production**.** *Bacillus aereus* was superior in suppressing the disease.

MJN 05. Comprehending the complex rubber (*Heveabrasiliensis*) genome through Linkage Mapping and Genome wide association studies to provide new insights on its disease tolerance mechanism

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The Para rubber tree is the major source of natural rubber in the world. *Phytophthora* spp., *Corynespora cassiicola* and *Colletotrichum* spp. are the major pathogens causing diseases in rubber tree. Marker-assisted selection is a powerful tool in breeding as it helps in selecting individuals possessing disease tolerance at an early stage of plant growth. F1 progenies derived from an interspecific cross between *H. brasiliensis* and *H. benthamiana* were utilized for constructinglinkage maps through genotyping by sequencing technique. Quantitative trait loci markers for these three diseases were identified. Genome Wide Association Study (GWAS) was initiated using a collection of 165 Wickham clones and evaluating their disease resistance to these three major pathogens. Extreme phenotypes (highly resistant and highly susceptible) were selected for each of the pathogen and six panels were created (two each for three pathogens). Equal concentrations of genomic DNA from each clone within a panel was pooled and sequenced. One hundred SNP markers specific to each pathogen and linked to disease tolerance trait were shortlisted and are being validated. This combined approach of linkage mapping with association mapping will help to cross validate the effective QTLs prior to their use in marker-assisted selection for disease resistance.

MJN 06. Etiology, epidemiology and management of bacterial leaf stripe of arecanut

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Bacterial leaf stripe of arecanut is an emerging disease that attacks early stage of the crop growth with the age group between 1-6 years and causes serious threat to arecanut cultivation leading to significant economic loss. Considering the magnitude of this disease, investigations were undertaken to study the pathogen and disease thoroughly in bringing out appropriate management aspects to mitigate the disease effectively. Survey conducted during 2019-20 and 2020 – 21 revealed that, the highest disease incidence and severity was noticed in Davanagere district and there was no disease incidence and severity in surveyed areas of Tumakur and Uttara Kannada districts. The growth of bacterium on seven different solid media showed considerable differences with respect to colony colour, size, shape, appearance and mucoidness. NGA media supported good growth of all the isolates. The biochemical profiling of the pathogen isolates

revealed that, the isolates shown positive reaction to catalase test, liquefaction of gelatin, KOH test, methyl red test ammonia production, starch hydrolysis and hydrogen sulphide production. Whereas, the negative reactions were observed in fluorescent test and gram staining. 1500 bp region of 16S rRNA gene was amplified and 500 bp region of *gyr*B was targeted from pathogen isolates through polymerase chain reaction (PCR) using 16S rRNA and *gyr*B specific primers. The samples are sequenced and the sequences are submitted to NCBI Gen bank and the following accession numbers were obtained MZ562788, MZ562784, MZ569849, MZ569506, MZ564395 and MZ569848. The pathogen was confirmed as *Xanthomonas vasicola* pv. *arecae*. Intermittent rainfall, temperature maximum of 35.53 to 35.60 0C and temperature minimum 21.26 to 21.80 0C, RH maximum of 83.29 to 77.00 per cent and RH minimum of 50.57 to 37.00 per cent were found favourable for the disease development and severity during 2019-20 and 2020-21. *Trichoderma harzianum* found to effective bio-agent under *In-vitro*. Kasugamycin + Copper oxychloride (Conica) was found to be effective chemical under *In-vitro*. Under field conditions Kasugamycin + Copper oxychloride (Conica) @ 1.25 g/liter treated plots showed reduced disease severity when compared to untreated control.

MJN 07. Host- Pathogen interaction between sugarcane and *Colletotrichum falcatum*: unravelling the host defense through biochemical and genomic approaches

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Sugarcane is a major field crop with economic importance cultivated worldwide. It succumbs to various diseases, among which fungal disease red rot caused by *Colletotrichum falcatum*is a dreadful disease. To manage the disease, we need to understand the host defense mechanism during pathogenesis. In this study, eGFP expressing *C. falcatum* was developed and used*in planta* histological studies, where stage-specific pathogenesis was assessed in detail during compatible and incompatible interactions. Also, histopathological assays were optimized in sugarcane settlings to reduce the time and it opens a new perspective in *C. falcatum* pathogenicity. Further, phytoalexin 3-deoxyanthocyanidin compounds apigeninidin and luteolinidin were identified, purified and their antifungal activity was established *in vitro* during compatible and incompatible interactions. The metabolomic analysis using GC-MS analysis revealed differential accumulation of antifungal compounds in sugarcane varieties. In addition, the defense response of phytoalexin accumulation correlated with phytoalexin pathway gene expression in the varieties. In this study, microRNA role during host defense was explored by constructing six miRNA libraries in which 80 miRNA families consisting 980 miRNAs were found along with novel miRNAs targeting various genes involved in metabolic process, cellular process, and stress responses. The expression analysis of miRNAs and their target genes revealed a prominent role of miRNA during the compatible and incompatible interactions and the miRNAs were found to have a negative regulation in most target gene expressions. The

biochemical and genomic approaches in the study gave more insights into the host defense mechanism, which is further incorporated in the management of red rot.

MJN 08. Microbial consortia a novel approach for the management of foot rot of wheat caused by *Sclerotium rolfsii* Sacc.

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The microbial consortium (combination of microorganisms that interact synergistically) are being currently used for crop protection over single bio inoculant. A microbial consortium is two or more microbial groups living symbiotically. Microbial consortia are much more efficient than single strains of organisms with diverse metabolites capabilities. Application of bioagents as a consortium may improve efficacy, reliability and consistency of the bioagents even under diverse soil and environmental conditions. Biocontrol attributes are also more in consortia in comparison to using single isolates. Foot rot of wheat caused by *Sclerotium rolfsii* is a major problem in the rainfed areas of Karnataka. The pathogen is a soil borne and damaging the crop by causing pre and post emergence death from seedling stage to maturity of the crop causing seedling death to an extent of 20 -25 per cent. Considering the benefits of microbial consortia over sole and separate application of biopesticides, the current investigation entitled "Microbial consortia a novel approach for the management of foot rot of wheat caused by *Sclerotium rolfsii* Sacc." has been experimented.

The fungal bioagents *Trichoderma harzianum* (IOF strain, Acc No. MH027645.1) and *Neofusicoccum parvum* (Endophyte) and bacterial bioagents *Pseudomonas fluorescens* (IOF strain, NAIMCC-B-01981) and *Bacillus subtilis* (MT383652.1) were found compatible to each other under *in vitro* condition. All the bioagents alone and in combination were found to be effective against *S. rolfsii* under *in vitro*. Pathogen inhibition was more potential in microbial consortia in comparison to single bioagents. Maximum inhibition (80.37%) was recorded in the combination of *T. harzianum* + *P. fluorescens* + *B. subtilis* + *N. parvum* over all other treatments.

The pot experiment revealed that the consortia of *T. harzianum* + *P. fluorescens* + *B. subtilis* + *N. parvum* was significantly effective in managing the disease in both seed treatment alone (30.00%) and seed treatment followed by soil drenching (26.67%) compared to single bioagents treated pots. The plant growth parameters like root length, shoot length and number of leave were higher in consortium treated pots compared to single bioagents. The biochemical tests (HCN, Siderophore and Chitinase) revealed that, *T. harzianum* tested positive for HCN and Chitinase, *P. fluorescens* tested positive for siderophore, *B. subtilis* tested positive for HCN, siderophore and *N. parvum* tested positive for all three tests conducted. The diversity in biocontrol mechanisms offered by each bioagent consortium may help in enhancing disease suppressiveness and may also strengthen the capabilities of the partners in an additive or

synergistic manner. Thus, there is a scope for use of microbial consortia with multiple mode of actions to manage the soil borne diseases under organic agriculture.

MJN 09. *Bacillus velezensis* (YEBBR6) promote plant growth and induce defense genes transcript in banana leading to the suppression of *Fusarium oxysporum* f. sp. *cubense*

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Global banana production is highly threatened by Fusarium wilt disease, caused by the soil- *Fusarium oxysporum* f. sp. *cubense* (*Foc*). Bacterial endophytes play a vital role in plant immune modulation and can confer resistance against plant pathogens by direct antagonism or via the host by triggering induced resistance. *Bacillus velezensis*, a bacterial endophyte isolated from the *Foc* resistant banana cultivar YKM 5, inhibited *Foc* mycelial growth by up to 65 percent while producing a variety of biomolecules during interaction. During interaction with *Foc*, *B. velezensis* produces biomolecules such as 5-hydroxymethyl furfural and clindamycin, which have significant antagonistic activity against *Foc*. *Insilico* studies revealed that biomolecule Clindamycin has effective binding energy against various virulence proteins targets of *Foc*. The endophytic *B. velezensis* was used for biohardening of the micropropagated banana plantlets cv. Grand Naine (AAA) during the primary and secondary hardening stages. Biohardening of banana plantlets with endophytic *B. velezensis* significantly suppressed Fusarium wilt disease and enhanced the plant's growth promotion activities. The transcript levels of defense response genes such as WRKY 33, MAPK, PAL, ERF, ACC, LOX, SA, JA and Catalase were significantly higher in plants treated with *B. velezensis* and remained significantly higher at 72 h post-inoculation compared to the inoculated control.

MJN 10. Investigations on epidemiology, molecular characterization and management of *Phytophthora meadii* (McRae) causing fruit rot of arecanut

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Fruit rot (*Phytophthora meadii*) has appeared as serious melody owing topmost threat to arecanut production leading to significant economic losses. Investigations were conducted to understand spatio-temporal distribution, morpho-molecular characterization, pathogenic and cultural variability, and farmers' friendly management aspects. Spatio-temporal analysis revealed the isotropic distribution of FRD in Malnad and coastal regions with disease severity (12.25 to 51.33 %) but contrast in Maidan region. Temporal dynamics revealed that the early initiation of the epidemic was witnessed at Malnad and Coastal regions in contrary to the Maidan region

where the disease was delayed up to fag end of the season. Morphological, pathological and molecular comparisons were made for 48 isolates of *P. meadii* obtained from varied geographical boundaries of Karnataka in respect of sporangial morphology, growth pattern, virulence assay, phylogenetic analysis and principal component analysis. Majority isolates were confirmed as *P. meadii* but some coastal region isolates showed association of *P. parsiana* based on morphological identification, cultural characteristics and multi locus gene sequencing (*ITS, TEF1-α, β-tub* and *Cox-II*). There were six morpho types, six colony groups, three fitness or virulence groups were identified which indicated high polymorphism, diversity and dynamic nature of the pathogen Foliar application of Mandipropamid 23.4% SC @ 5 ml/liter or Bordeaux mixture @ 1% and soil application Fosetyl-Al 80 % WP amended briquettes @ 100 g / palm at monthly interval were found significantly effective in reducing the fruit rot disease severity with increased yield under natural epiphytotic conditions.

TECHNOLOGIES DEVELOPED BY ICAR- CPCRI

FOOD PROCESSING

1. VIRGIN COCONUT OIL

Virgin Coconut Oil is one of the most demanded product in global market. Due to its high medicinal and cosmetic value it is accepted by all class of customers across the globe. VCO is very useful for fat loss, improving immunity of the body, removing dandruff, skin purification, reduce cholesterol etc. We have developed a complete package for the producing the most purest form of Virgin Coconut Oil. We have two methods of VCO production, namely Hot process and Fermentation or cold process. Technology transfer fee : 40,000/-

VIRGIN COCONUT OIL


COCONUT CHIPS

2. COCONUT CHIPS

It's a ready to eat crispy, crunchy and healthy snack prepared by osmotic dehydration and subsequent drying of coconut kernel at 70 degree temperature. It can be prepared in various flavors like vanilla, strawberry, pineapple, chat masala, tomato etc. It is highly rich in fiber and nutrients.

3. SNOWBALL TENDER COCONUT

To make 'snow ball tender nut', the white kernel scooped out from the tendernut without shell with the water inside intact.


SNOWBALL TENDER COCONUT


KALPARASA

4. KALPARASA

Kalparasa' a fresh, hygienic and unfermented energy drink from coconut inflorescence .Developed coco-sap chiller technology collects coconut sap (neera) fresh, hygienic and unfermented without the addition of chemicals or preservatives. Sap collected under cold temperature by this method is original with natural flavor and aroma and highly amenable for further processing as health drink . As it is zero alcoholic with all the natural flavors intact and different from traditionally collected neera it is christened as Kalparasa.

5. PALMSUGAR

Developed coco-sap chiller technology collects coconut sap (neera) fresh, hygienic and unfermented without the addition of chemicals or preservatives. Sap collected under cold temperature by this method is original with natural flavor and aroma and highly amenable for further processing as health drink or other value added products like coconut sugar, jaggery, syrup or concentrate.


PALMSUGAR


CARBONATED TENDER COCONUT WATER

6. CARBONATED TENDER COCONUT WATER

In this technology we will provide you hands on training for preserving of carbonated tender coconut water. It can be preserved more than 60 days. Its very healthy ready to drink nutritious carbonatedbeverage. Its a very refreshing drink and have a peak demand in the market. As we are not adding another other external source of preservative/chemical, it delivers the exact taste of tender coconut water.

7. COCONUT NATURAL VINEGAR

Its is a package of technologies. In this we provide training on production of coconut vinegar, coconut squash, coconut jelly and other products which can be prepared from matured coconut water. By opting this technology alone with the technology of other coconut value added product, we can make use of coconut water to convert to usable value added products, rather than dumping it out.


COCONUT NATURAL VINEGAR

KALPA KRUNCH

8. KALP KRUNCH

It is prepared from coconut residue obtained after extracting the coconut milk. In shape and texture wise it is similar to the product "Kurkure" of Pepsico company ltd, but totally different in the content and taste. If is highly nutritious and healthy snack which will be preferred by all class of customers. It can be prepared in different flavors, as of now, we have developed tomato flavor, masala, sweet and coriander.


COCONUT FROZEN DELICACY

9. COCONUT FROZEN DELICACY

People are concerned with health related issues arising from consumption of ice cream and frozen delicacies for cholesterol and high calories. To meet the demand of health-conscious CPCRI developed the coconut frozen delicacy. Vegan Frozen Delicacy is made out of coconut milk, coconut sugar, tender coconut water and pulp

KALPA BAR CHOCOLATE

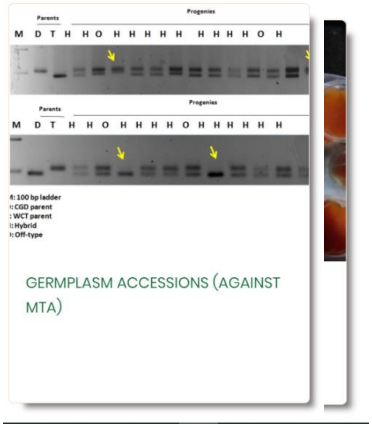
10. KALPA BAR CHOCOLATE

Kalpa bar chocolate is moulded in 30 g packs and is a rich blend of pure cocoa and natural coconut sugar and has the delicious richness of dark chocolate. It does not contain any artificial ingredients.

KALPA DRINKING CHOCOLATE

11. KALPA DRINKING CHOCOLATE

Kalpa drinking chocolate is packed in 200 g pet jars and is an instantised blend of low GI coconut sugar, crafted from fine cocoa powder formulated to produce the delicious drinking chocolate. It is good for the taste buds of drinking chocolate lovers who want a healthier life style.



12. COCONUT WATER JELLY

Its is a package of technologies. In this we provide training on production of coconut vinegar, coconut squash, coconut jelly and other products which can be prepared from matured coconut water. By opting this technology alone with the technology of other coconut value added product, we can make use of coconut water to convert to usable value added products, rather than dumping it out.

PRODUCTION AND PLANTING MATERIAL

1. POLLEN FROM SELECTED VARIETIES/GERMPLASM (MTA)

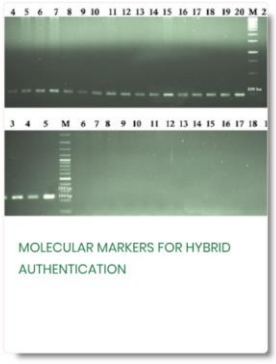
Viability and fertility studies using cryopreserved coconut pollen Pollen of both WCT and COD cultivars retained its viability and fertility even after a storage period of 4 years in liquid nitrogen.

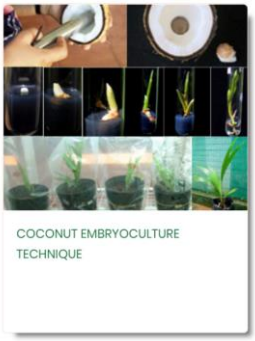
2. RELEASED VARIETIES

Released twelve improved varieties of coconut (Chandra Kalpa, Kera Chandra, Chowghat Orange Dwarf, Kalpa Pratibha, Kalpa Dhenu, Kalpa Mitra, Kalparaksha, Kalpasree, Kalpatharu, Kalpa Jyothi, Kalpa Surya and Kalpa Haritha)
Released five high yielding hybrids of coconut - Chandra Sankara, Kera Sankara, Chandra Laksha, Kalpa Samrudhi and Kalpa Sankara.
Released six high yielding varieties (Mangala, Sumangala, Sreemangala, Mohitnagar, Swarnamangala and Kahikuchi) and two hybrids of arecanut (VTLAH1 and VTLAH2).

3. GERMPLASM ACCESSIONS (AGAINST MTA)

DNA finger printing using microsatellite markers have been carried out in 139 coconut accessions to document the genetic integrity and diversity. A panel of SSR markers have been identified for confirming the hybridity of D x T hybrids (CGD x WCT) which will ensure supply of genuine hybrids to farmers.



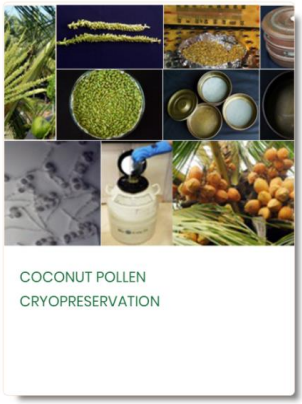


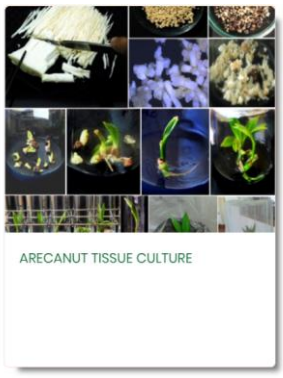
4. COCONUT EMBRYO CULTURE TECHNIQUE

Protocol for regeneration of coconut plantlets from plumule explants through somatic embryogenesis developed.

5. COCONUT POLLEN CRYOPRESERVATION

Cryopreservation techniques have been standardized for mature coconut zygotic embryos and coconut pollen.





6. ARECANUT TISSUE CULTURE

Tissue culture protocol has been standardised for mass multiplication of arecanut from inflorescence explants and genetic fidelity of in vitro derived plantlets has been assessed using molecular markers.

ORGANIC AND OTHER INPUTS FOR FARMING

KALPA SOIL CARE (UREA FREE COIR PITH COMPOSTING)

1. KALPA SOIL CARE (UREA FREE COIR PITH COMPOSTING)

The urea-free coir-pith compost produced using cocomposting technology is available at ICAR-CPCRl under the brand name 'Kalpa Soil Care'.

KALPA ORGANIC GOLD (VERMICOMPOSTING OF COCONUT LEAVES)

2. KALPA ORGANIC GOLD (VERMICOMPOSTING OF COCONUT LEAVES)

The vermicompost produced from coconut leaves using the technology developed at ICAR-CPCRI is now available by the trade name 'Kalpa Organic gold'.

KERA PROBIO (PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR) FOR COCONUT)

3. KERA PROBIO (PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR) FOR COCONUT)

Farm-based method for bioinoculant production. 'Kera Probio', a talc formulation of Bacillus megaterium, effective for raising robust coconut seedlings has been developed at ICAR-CPCRI.

COCAO PROBIO (PGPR FOR COCOA)

4. COCAO PROBIO (PGPR FOR COCOA)

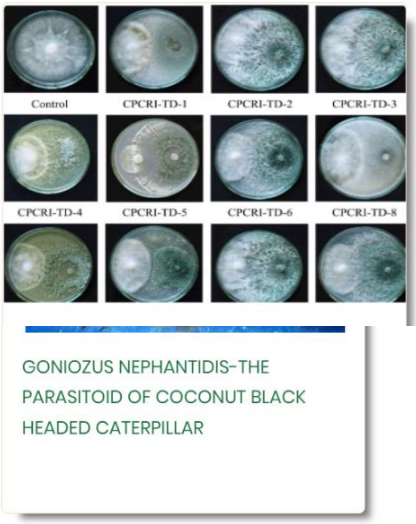
Farm-based method for bioinoculant production.A farmer-friendly method for mass-production of bioinoculants utilizing a blend of mature coconut water, rice gruel and biochar, which are locally available, was standardized. Using this method, contaminant-free bioinoculants can be mass-produced from starter cultures by farmers themselves, on their own farm, for immediate field application.

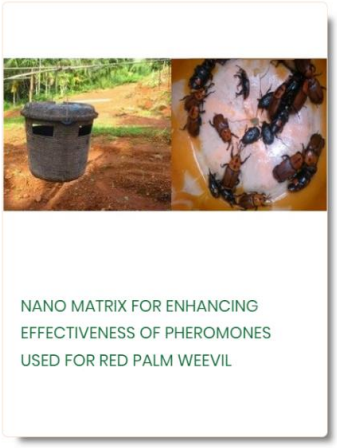
5. METARHIZIUM ANISOPLIAE, THE GREEN MUSCARDINE FUNGUS AGAINST RHINOCEROS BEETLE

ICAR-CPCRI has found a potent green muscardine fungus, Metarhizium anisopliae that could control the beetle. Spores of M. anisopliae enter on cuticular contact and kill the grubs in a fortnight. A dosage of 5×1011 spores per cubic metre of pest breeding material is recommended for field application.

6. GONIOZUS NEPHANTIDIS-THE PARASITOID OF COCONUT BLACK HEADED CATERPILLAR

Biological suppression of coconut black headed caterpillar *Opisina arenosella*. The leaf eating black headed caterpillar *Opisina arenosella* is a serious pest of coconut palm causing significant yield loss in the coconut growing tracts of India. larval parasitoids *Bracon brevicornis* and *Goniozus nephantidis* were carried out in pest affected gardens.





7. NANO MATRIX FOR ENHANCING EFFECTIVENESS OF PHEROMONES USED FOR RHINOCEROS BEETLE

Beetles were caught in the pheromone traps varied with concentrations, 98 and 108 rhinoceros beetles were caught in pheromone traps baited with pheromone lure 750 and 1000 mg concentrations, respectively, and were found significantly superior than other treatments.

8. NANO MATRIX FOR ENHANCING EFFECTIVENESS OF PHEROMONES USED FOR RED PALM WEEVIL

Nanomatrix loaded pheromone trap was found to be effective in trapping red palm weevil of coconut.

9. TRICHODERMA AGAINST DISEASES

Trichoderma a genus under *Ascomycotina*, has gained immense importance since last few decades due to its biological control ability against several plant pathogens. In addition, the increased growth response induced by *Trichoderma* species has also been reported for much kind of crops.

10. TRICHODERMA CAKE

Trichoderma Coir Pith Cake and cup formulation (TCPC) for management of bud rot disease of coconut and stem canker and seedling blight disease of cocoa. A technology has been developed to prepare a Trichoderma formulation viz., Trichoderma coir pith cake & cup (TCPC) using coir pith, 'maida' flour and Trichoderma harzianum (CPTD 28) biomass.

11. KALPA EPN (CPCRI - SC1)

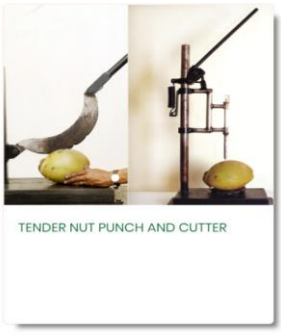
Bio-agent for control of grubs and caterpiller as part of IPM in plantation agro-ecosystem.

MACHINERY AND GADGETS

1. COCONUT DESHELLER FOR SEPARATING COPRA

The Coconut De-Shelling Machine is to remove shell from partially dried copra of moisture content 35 % d.b. The batch type machine has a capacity of de-shelling 200 coconuts per batch. For separating shell and copra after partial drying.

COCONUT DESHELLER FOR SEPARATING COPRA



TENDER NUT PUNCH AND CUTTER

2. TENDER NUT PUNCH AND CUTTER

For drinking tender nut water.

3. TELESCOPIC SPRAYER FOR PALMS

Telescopic sprayer for Palms (Patent: 246751) For spraying palms from the ground up to 40ft height.

TELESCOPIC SPRAYER FOR PALMS

COCONUT DESHELLING MACHINE

4. COCONUT DESHELLING MACHINE

The coconut shell removing machine reduces both time and drudgery involved in the manual de-shelling process. It also gives coconut kernal in single piece so that testa removing would be easy. The machine is quite gender friendly, even a lady can operate the machine with minimum experience. The machine has a capacity to remove the shell of 120 coconuts per hour. An experienced person could achieve a capacity of 150 coconuts per hour.

5. TESTA REMOVER

For the removal of coconut testa for production of coconut chips and virgin coconut oil. The machine consists of a circular wheel covered with an emery cloth or water paper. This friction wheel is rotated using an electric motor. Coconut kernel is pressed to the surface of the rotating friction wheel either by hand or using a fork. Removed testa is collected at the bottom.

TESTA REMOVER

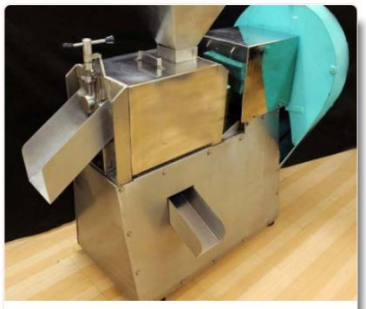
PULVERISER

6. PULVERISER

To pulverize the coconut kernal. The coconut meat, free from testa, is fed to a Coconut pulverizer, after splitting coconut into two halves, are pressed manually to the rotating blade of the machine for grating.

7. DOUBLE SCREW COCONUT MILK EXPELLER

To extract coconut milk.



DOUBLE SCREW COCONUT MILK EXPELLER

VCO COOKER (BIOGAS/LPG)

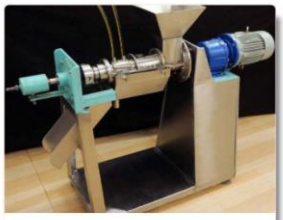
8. VCO COOKER (BIOGAS/LPG)

To extract virgin coconut oil from coconut milk. If the coconut milk is directly used in slow heating process it will take a much longer heating time to recover oil. Coco cream is placed in a double walled boiler known as VCO cooker developed at CPCRI.

9. VCO COOKER (AGRL WASTE FUEL)

To extract virgin coconut oil from coconut milk. If the coconut milk is directly used in slow heating process it will take a much longer heating time to recover oil. Coco cream is placed in a double walled boiler known as VCO cooker developed at CPCRI.

VCO COOKER (AGRL WASTE FUEL)



SINGLE SCREW COCONUT MILK EXPELLER

10. SINGLE SCREW COCONUT MILK EXPELLER

To extract coconut milk

11. HYDRO-PNEUMATIC MILK EXTRACTOR

To extract coconut milk

HYDRO-PNEUMATIC MILK EXTRACTOR

ELECTRICAL SLICER

12. ELECTRICAL SLICER

To make coconut slices.

COCONUT CHIPS DRYER (AGRL WASTE FUEL)

13. COCONUT CHIPS DRYER (AGRL WASTE FUEL)

To dry coconut chips

SAFETY DEVICE COCONUT CLIMBING MACHINE

14. SAFETY DEVICE COCONUT CLIMBING MACHINE

When attached the safety device provides fool proof safety to the person climbing coconut using the Chemberi model coconut climbing machine

SNOW BALL TENDER NUT MACHINE

15. SNOW BALL TENDER NUT MACHINE

To make 'snow ball tender nut', the white kernel scooped out from the tendernut without shell with the water inside intact.

COPRA DRYER – 500 NUTS; SHELL-FUEL

16. COPRA DRYER – 500 NUTS; SHELL-FUEL

To make quality copra

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Azadi Ka Amrit Mahotsav