International Conference

Role of Soil and Plant Health in Achieving Sustainable Development Goals

November 21-25, 2018 | Bangkok, Thailand

ABSTRACTS

Organizers

Indian Phytopathological Society (IPS), New Delhi
Asia-Pacific Association of Agricultural Research Institutions (APAARI)
Bangkok, Thailand
Department of Agriculture, Bangkok, Thailand

IRRI
ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
Australian Government
Australian Centre for International Agricultural Research

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International Conference on Role of Soil and Plant Health Towards Achieving Sustainable Development Goals

21-23 November 2018, Hotel Rama Gardens, Bangkok

(Program)

Day 1: Wednesday, 21 November 2018		
Venue: Tulip Hall		
08:15-09:00	**Registration**	
09:00-10:30	**Inaugural Session**	
	Welcome and Background of the Conference	Ravi Khetarpal, APAARI, Thailand
	Remarks Dignitaries	Warawut Chootummatouch, DOA, Thailand
		Louise Whiting, FAO RAP, Thailand
		Yuxin Tong, FAO Hqrs, Italy
		R.N. Pandey, IPS, India
	Message	H.E. Chen-Yuan Tung, Representative, TECO, Thailand
	Release of Publications by Chief Guest	H.E. Luck Wajananawat, Deputy Minister of Agriculture and Cooperatives, Thailand
	Inaugural Address by the Chief Guest	H.E. Luck Wajananawat, Deputy Minister of Agriculture and Cooperatives, Thailand
	Vote of Thanks	
10:30-11:00	***Group Photograph and Tea/Coffee Break***	
Keynote Address **Co-chairs**: Pearl B Sanchez, Siva Annamalai **Rapporteurs:** CL Acharya, KS Varaprsad		
11:00-11:40	Sustainable Development Goals and Soil Health – Global and Asian Soil Partnerships	Yuxin Tong, FAO, Rome Pitayakon Limthong, Bangkok
	Plant Health Scenario and Sustainable Development Goals in Asia Pacific	Ravi Khetarpal, APAARI, Bangkok

Technical Session I: Regional Initiatives and Priorities of Soil Health for Research and Development **Co-chairs**: Yuxin Tong, Girish Chander **Rapporteur:** Margaret Yoovatana		
(11:40-13:00) – (14:00-15:30)	**South and West Asia**	
	Bangladesh	Nirmal Chandra Shil, BARI
	Bhutan	Tashi Uden, DOA
	India	S.K. Chaudhari, ICAR
	Nepal	Mr. Krishna Bahadur Thapa, NARC
	Pakistan	Fayyaz Hussain PARC
	Sri Lanka	H.A.S. Weerasinghe, SLCARP
	Iran	Karim Shahbazi, AREEO
	Discussions	
	Lunch (13:00 – 14: 00)	
	South East Asia and Pacific	
	Japan	Naruo Matsumoto, JIRCAS
	Taiwan	Yu-Wen Lin, COA
	Lao, PDR	Singlty Voradeth, NAFRI
	Malaysia	Theeba Manikam, MARDI
	Philippines	Pearl B. Sanchez, PCAARRD
	Vietnam	Tran Minh Tien, MARD
	Thailand	Somchai Anusontpornperm, KU
	Papua New Guinea	Akkinapally Ramakrishna, NARI
	Discussions	
15:30 – 16:00	***Tea/Coffee Break***	

Technical session II: Climate Change, Sustainability and Value Chain **Co-chairs:** SS Chahal, Yu-Wen Lin **Rapporteur:** V. Celia Chalam		
Venue: Tulip Hall		
16:00-17:30	**Key note Lecture:** Sustaining agricultural productivity under climate change scenario in Asia Pacific – Rice as a case study	U.S. Singh, IRRI
	ASEAN Farmers: Soil health champions in Asia	Jesie S. Binamira, FAO Consultant
	Soil health management - issues & concerns for sustainable development	Girish Chander, ICRISAT
	Soil health : research and development	Bunjirtluk Jindaridth, DOA
	Soil as a carbon sink	Pradeep Sharma, SKUAST
	Potential impacts of climate change on plant pathogens and biocontrol agents and adaptation strategies	Suseelendra Desai, ICAR-CRIDA
	Role of soil health in achieving sustainable development goals	Himanshu Pathak, ICAR-NRRI
	Importance of plant health in value chain	Sivapragasam (Siva) Annamalai, CABI
	Microbes for improving soil and plant health in spice crops	M. Anandaraj, Ex-ICAR-IISR
	Perspectives and challenges of plant growth promoting rhizobacteria application for crop improvement- A case study	S.R. Niranjana, GU
	Discussions	
18:00-20:00	***Reception Dinner***	

Day 2: Thursday, 22 November 2018		
Technical session III: Regional Initiatives and Priorities of Plant Health for Research and Development **Co-chairs:** A.N. Mukhopadhyay, Srinivasan Ramasamy **Rapporteur:** VK Baranwal		
Venue: Tulip Hall		
08:30 – 11:00	**South Asia**	
	Bangladesh	Dilwar Ahmed Choudhury, BARI

	Bhutan	Tashi Uden, DOA
	India	C.D. Mayee, Ex-ICAR-ASRB
	Nepal	Deepak Bhandari, NARC
	Pakistan	Umer Iqbal, PARC
	Sri Lanka	G.D. Sinniah, SLCARP
	South East Asia and Pacific	
	Japan	Naruo Matsumoto, JIRCAS
	Taiwan	Yu-Wen Lin, COA
	Vietnam	Nguyen Hong Son, MARD
	Lao, PDR	Singlty Voradeth, NAFRI
	Philippines	Anthony B. Obligado, BAR
	Thailand	Pattara Opadith, DOA
	PNG	Akkinapally Ramakrishna, NARI
	Samoa	Kuini Tupou Tagai, MAF
	SPC	Siosiua Halavatau, SPC, Fiji
	Discussions	
	Tea/Coffee Break	
Technical Session IV A and IV B (Concurrent Sessions)		
11:30-12:30	**Technical session IV A : Knowledge Management, Outreach and Commercialization** **Co-chairs:** Dileepkumar Guntuku, JP Sharma **Rapporteur:** Fai Collins (Venue: Tulip Hall)	
	Role of digital technologies	Dileepkumar Guntuku, ISU, USA
	Coordination among phytopathological societies for quality: improvement	S.S. Chahal, Ex-VC, MPUAT
	Commercialization of *Trichoderma* spp. and other bio-agents for management of stresses in crops vis –a- vis for prosperity of developing nations	R.N. Pandey, Ex-AAU
	Views on reaching the farmers in an innovative way	M.P. Thakur, IGAU
	Discussions	

11:30-12:30	**Technical Session IV B - Poster Presentations (Sessions for Highlights of posters)** **Co-chairs:** SM Paul Khurana, MB Cheti **Rapporteur:** Kajal K Biswas (Venue: **Canna Hall**)	
12:30-13:30	***Lunch***	
13:30-15:30	**Technical session V: Eco-friendly approaches for Soil and Plant Health Management** **Co-chairs:** C.D. Mayee, Pattara Opadith **Rapporteur:** Vaibhav Kumar Singh (Venue: Tulip Hall)	
	Key note Lecture: Plant disease management with ecofriendly biopesticides	A.N. Mukhopadhyay, Ex-VC, AAU
	Soil agroecology and common microbial biotechnology platform	Mary Atieno, CIAT
	Eco-friendly approaches for soil and plant health management in tropical vegetable production	Srinivasan Ramasamy, WorldVeg,
	Disease management through host plant resistance	Rajan Sharma, ICRISAT
	Strategies for biomanagement of Fusarium wilt of banana	S.M. Paul Khurana, AU
	Role of soil amendments in improving degraded medium to coarse-textured soils for upland crop practices in Northeast, Thailand	Suphicha Thanachit, KU
	Management of bacterial wilt of tomato incited by *Ralstonia solanacearum* through bacterial antagonists	Dinesh Singh, IARI
	Trichoderma as biological control agent for integrated disease management and healthier soil and plant for sustainable agriculture	S.C. Dubey, ICAR-NBPGR
	Endophytic fungal bioagents in plant disease management	Pratibha Sharma, KNAU
	Phyto-Mediated Recovery of Soil Health	Rita S. Majumdar, SU
	Discussions	
15:30-16:00	***Tea/Coffee Break***	

16:00-17:00	**Technical Session VI: Quarantine, Diagnosis, Taxonomy and Biodiversity** **Co-chairs:** C. Manoharachary, Rajan Sharma **Rapporteur:** Suseelendra Desai (Venue: Tulip Hall)	
	Diagnosis and management of plant health using new Information and communication technology	M.P. Thakur, IGAU
	Current research on diagnosis and management of citrus greening disease in India	Dilip K. Ghosh, ICAR-CCRI
	Novel approaches for rapid virus detection of plant viruses: A case study of banana viruses	V.K. Baranwal, ICAR-IARI
	Role of quarantine in biosecurity against plant viral diseases in Asia-Pacific: Challenges	V. Celia Chalam, ICAR-NBPGR
	Minimizing risk of introduction of exotic pathogens associated with Import of plant genetic resources into India	Jameel Akhtar, ICAR-NBPGR
	Exploration of undiscovered fungi of Meghalaya State of North East Region of India	R. Sudeep Toppo, ICAR-IARI
	Identification, characterization and detection of viruses associated with orchids in Sikkim and Darjeeling hills of West Bengal	Rajendra P. Pant, ICAR-IARI
	Genomic features of an Indian isolate of rice false smut pathogen *Ustilaginoidea virens*	D. Pramesh, UAS
	Fungal Endophytes: A treasure trove of biodiversity, host security, antimicrobial and myconanotechnology	Ravindra Nath Kharwar, BHU
	Bipolaris - Curvularia - Cochliobolus Complex – their phylogenetic and taxonomic re-evaluation and DNA barcoding	T. Prameela Devi, ICAR-IARI
	Mycorrhizal diversity of weed species in degraded and deficient Land ecosystems	U.N. Bhale, ASC College
	Avirulence gene based profiling of *Magnaporthe oryzae* field isolates from South India and virulence analysis of rice blast isolates on monogenic lines	Prashanthi S.K., UAS
	Discussions	

13:30-15:30	**Technical Session VII: Plant Health Management - Case Studies** **Co-chairs:** G.D. Sinniah, Umer Iqbal **Rapporteur:** Dilip K. Ghosh (Venue: Canna Hall)	
	Wheat blast - A recent danger to wheat production in South Asia and our preparedness	Vaibhav Kumar Singh, ICAR-IARI
	Current status of Cotton leaf curl begomovirus complex in India: disease incidence, genomics, virus distribution and molecular basis pathogenicity,	Kajal K. Biswas, ICAR-IARI
	Management of Wheat streak mosaic virus, an emerging disease of the wheat	Jiban Kumar Kundu, CRI, Czech Republic
	Eco-friendly management of banded leaf and sheath blight of maize,	R.C. Mathuria, ICAR-IARI
	Biochemical and molecular basis of chemically induced defense activation in maize against banded leaf and sheath blight disease	Robin Gogoi, ICAR-IARI
	Status of major diseases of Makhana in Koshi Region of Bihar and correlation of weather parameters with alternaria leaf blight and spot	Santosh Kumar, BAU
	Alternaria disease- an emergent problem of litchi (*Litchi chinensis*) in India	Vinod Kumar, ICAR-NRC on Lichi
	Harnessing the potential of bio-inoculants for disease management and soil health	Krishna Kumar, ICAR-IIPR
	Mitigating drought stress in rice using *Trichoderma harzianum*	Ramji Singh, SVBPU
	Combined effects of soil salinity and some agrochemicals on growth of Rhizobia	S.S. Kamble, SU
	Studies on black rot cabbage caused by *Xanthomonas campestris* pv. *campestris*	K.B. Yadahalli, UAS
	XopC2 T3SS effector of *Xanthomonas axonopodis* pv. *punicae* suppresses pomegranate immune responses to support bacterial growth during blight development	Kalyan K. Mondal, ICAR-IARI
	Improvement of soil health through enriched spent mushroom substrate (SMS) and its effects on plant health, productivity and wilt incidence of tomato	Mohan Kumar Biswas, IA-Visva-Bharati
	Correlation of weather parameters with development of Alternaria leaf blight of gerbera	Reshmy Vijayaraghavan, KAU
	Discussions	
15:30-16:00	***Tea/Coffee Break***	

16:00-18:00	**Technical session VIII: Plant Health Management – Research Trends** **Co-Chairs**: Anthony B. Obligado, Tashi Uden **Rapporteur**: Robin Gogoi (Venue: Canna Hall)	
	Integrated capability of supplementary agrochemicals on the growth of carbendazim resistant Botrytis cinerea causing leaf and flower blight of rose	M.B. Waghmare, The New College, Kolhapur
	Influence of biofertilizer and biocontrol agents on medicinal and aromatic plants	Asha Chaubey, CSIR-IIIM
	Modelling of diseases of sunflower under changing climatic scenarios in southern Karnataka	K. Karuna, UAS, GKVK
	Management of leaf rust and insects of wheat by new pre-mix molecule	I.K. Kalappanavar, UAS
	Role of endophytes in mitigating soilborne fungal diseases of groundnut	Yashoda R. Hegde, UAS
	Arbuscular mycorrhizal fungal association in indigenous scented black rice (*Oryza sativa* L.) and effect of bioinoculants on its growth and yield in North Eastern India	Radha Raman Pandey, MU
	Impact of bio-agents on blast, sheath blight, bacterial blight and drought tolerance in rice	Akshaya Kumar Senapati, OUAT
	Evaluation of resistant tomato germplasm against tomato yellow leaf curl disease to improve crop productivity in Oman	Muhammad Shahid, SQU
	Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS: A new molecule against the different diseases of Corn	Poly Saha, CAB
	Biosynthesis, characterization and antifungal activity of Silvernano Particles from Lactuca virosa	Sharwari K. Mengane, MHSM
	In vitro antifungal activity of plant latex extracts against resistant isolates of pathogens associated with ivy gourd	V.S. Chatage, KRMD
	Evaluation of Trichoderma spp. for biological control of charcoal rot of maize	S.G. Jagtap, SU
	Impact of seed treatments with biocontrol agents on major yield reducing soil borne pathogens of soybean	Shrishail S. Navi, LSU
	Plant health and UN sustainable development goals	DR Mohd. Ashaq Malik, GPGC
	Discussions	

Day 3: Friday, 23 November 2018		
Technical session IX: Panel Discussion **Policy and Capacity Development on Soil and Plant Health** **Co-Chair**: S.K. Chaudhari, S.R. Niranjana **Rapporteur**: Pratibha Sharma (Venue: Canna Hall)		
Implications 09:00-12:30	Flagging issues on soil health	C.L. Acharya
	Flagging issues on plant health	K. S. Varaprasad
	Capacity development for farmers on soil and plant health	Jainz Jinamira, Philippines
	Policy implications on soil health of Forestry	Chongrak Wachrinrat, KU
	Capacity development on plant biosecurity and biosafety in South Asia	Celia Chalam, ICAR-NBPGR
	Policy needs for soil health management	Yuxin Tong, FAO, Rome
	Socio-economic consideration for soil and plant health management	Norah Omot, APAARI
	Address Soil Health Issue for Policy and Capacity	Somchai Anusontpornperm, KU
	Policy issues related to microbes, fungi and plant pathogens with reference to soil and plant health	C. Manoharachary, OU
	Current scenario of biopesticides in India: Regulatory requirements for commercialization	H.B. Singh, BHU
	Need for transformation in Higher Education for achieving SDGs	Wayne Nelles, APAARI
	Capacity development in microbial biotechnology	Mary Atieno, CIAT
	Discussions	
12:30-13:00	***Lunch***	
Plenary Session **Co-chairs**: Yuxin Tong, Surmsuk Salakphet Ravi Khetarpal (Venue: Canna Hall)		
13:00-14:30	Consolidated recommendations of Sessions: Soil Health Plant Health	 C.L. Acharya K.S. Varaprasad
	Modalities for establishing a Regional Platform on Soil and Plant Health • Terms of reference, Governance, Funding, Location, etc	Yuxin Tong Surmsuk Salakphet U.S. Singh Chongrak Wachrinrat

	Remarks by Co-organizers	Surmsuk Salakphet, DOA R.N. Pandey, IPS U.S. Singh, IRRI
	Concluding Remarks by Co Chairs	
	Vote of thanx	Rishi Tyagi
Departure		

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Technical Session II

Climate Change, Sustainability and Value Chain

I.04: Potential impacts of climate change on plant pathogens and biocontrol agents and adaptation strategies

Suseelendra Desai
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Email: desai1959@yahoo.com

Indian agriculture is impacted by climate –variability and –change exerting pressure on food- and nutritional-security. Despite, India being food self-sufficient, frequent occurrence of extreme weather events could lead to regional imbalances. Literature shows that minimum temperature thresholds are on the rise, which could impact vulnerable phenophases of crops and thus reducing significantly the major food grain yields. Pathogens and crops have co-evolved over time with established host-pathogen relationships. However, host-pathogen relationships largely depend on prevailing weather and thus climate change could also alter stages and rates of development of the pathogen, modify host resistance, and modified physiology and biochemistry of host-pathogen interactions. The significant impacts could be in the form of i) hitherto less-known diseases (commonly called as minor diseases) becoming major problems; ii) Spread of the pathogens to new areas/crops; iii) emergence of new pathotypes; iv) disappearance of current host-pathogen relationships; v) new/modified pathogen-biocontrol agent interactions and vi) change in host-pathogen-biocontrol tritrophic interactions. These anticipated impacts are due to the response of current natural ecosystems to altered temperature and precipitation profiles. Although, the research in establishing the impacts of pathogens and their natural enemies is at its infancy, independent studies conducted across the laboratories show that considerable variations could be anticipated. In some crops, elevated CO_2 levels are known to increase foliar density which in turn will influence the microclimate of the pathogen, altered host morphology and thus influence host-pathogen interaction such as enhanced sporulation of anthracnose pathogen, and increased dry-root rot under moisture stress conditions. In case of vector-transmitted pathogens, a new dimension of climate change impacts on vectors also adds to the complexity. More than climate change for which slow adaptation also could be expected, extreme weather events like high- and low-temperature stresses; soil-moisture deficit stress; flooding, and hailstorms etc could play a vital role in modified host susceptibility; new/rapid development of the pathogen; more rapid vector development leading to faster spread of the pathogens; variable overwintering/over-summering of the pathogen/vector; and shift in spread pattern of the pathogens. The present paper reviews the interaction of different weather variables with plant pathogens, and the probable threats for food grain production, availability and quality.

L.01: Role of soil health in achieving sustainable development goals

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In 2015, United Nations again set its Agenda for 'Transforming Our World'. It identified 17 Sustainable Development Goals (SDGs) to address the issues of poverty, inequality, injustice and climate change by 2030. For the developing countries, the SDGs are very crucial and they should not miss the targets. Soil health is closely linked to the plant-animal-human-atmospheric–climate system through the carbon, nitrogen and water cycles. Over exploitation and mismanagement of soil, however has resulted in severe degradation without recognizing the inherent dangers. Problems of soil salinity, water logging, declining water table, deteriorating water quality, nutrient mining and acidification of soil would have tremendous impacts on agricultural production and hence food security of any region causing serious impediments in achieving the SDGs. Improving soil health is crucial for addressing climate change, one of the SDGs. Climate change manifested through change in precipitation patterns and amounts, and increase in temperature may degrade soil quality, reduce soil moisture content and affect microbial diversity. Increases temperature reduces quantity and quality of organic matter content, which is quite low in Indian soil. Increased surface temperature coupled with reduced rainfall may lead to accumulation of salts in soil. Rise in sea level associated with increased temperature may lead to salt-water ingression in coastal lands, making them unsuitable for agriculture. Emissions of greenhouse gases (GHGs), which are the causes of climate change can be reduced by improved soil and crop management, which offers opportunities for mitigation from the supply as well as demand sides. From the supply side, sustainable crop intensification with improved and climate-smart varieties, crop diversification; and improved nutrient, crop residue and water management can substantially reduce GHGs emission. In the demand side opportunities include sequestering carbon in soil, agro-forestry, bio-energy crops. Soil management also offers promises for climate change adaptation through modifying crop management practices, improving water, carbon and nutrient management and adopting new farm techniques such as resource conserving technologies. Though, there are significant opportunities for GHGs mitigation and adaptation in agriculture, but numerous barriers need to overcome. A win-win solution is to start with such mitigation and adaptation strategies that are needed for sustainable development. In the research front, there is a need for life cycle assessment with integrated, eco-regional approach including the participation of farmers and other stakeholders. We need to develop an integrated land use policy and invest more in land and water resources management, input delivery and market mechanisms to exploit the benefits of available technologies and achieve the SDGs.

I.02: Microbes for improving soil and plant health in spice crops

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India is known as land of spices and every region has its own spice to boast. Spices can be broadly classified into perennial spices comprising of black pepper, cinnamon, clove, and nutmeg largely confined to Southern states; seed spices namely cumin, coriander, fennel and fenugreek in major areas of Western and Northern region and zingiberaceous spices that include large and small cardamom, ginger and turmeric, grown in almost all parts of the country. The weather and soil conditions in the North Eastern region are ideal for spices cultivation for a better quality. To get a healthy crop the soil must also be healthy. Over the years the soil health status both in terms of physical and biological has been deteriorating. Soil borne diseases are major production constraints for spices caused by Oomycetes, *Ralstonia solanacearum* and plant parasitic nematode *Meloidogyne incognita*. Plant root surface are nutrient rich as the roots secrete sugars, amino acids and readily available nutrients and several microbial communities thrive here. Plants recruit the microbial communities as per their need, and there is intense competition in the rhizosphere when compared to bulk soil. Identification of efficient organisms, development of cost-effective formulation, setting standards for mass production and inoculation techniques makes cultivable microbes much more attractive research targets among numerous and diverse soil microbes. Beneficial microbial inoculants in agriculture are mainly plant growth-promoting rhizobacteria (PGPR) and fungi, and they function through different mechanisms to increase the plant fitness under biotic/abiotic stresses. Once the beneficial microorganisms are identified, it is cultured in the laboratory, mixed with a carrier medium and delivered to the field by making formulations with inert materials like talc and lignite. Use of peat, agricultural bye products like coffee husk, tea dust, whole grains of cereals and pulses are in vogue besides liquid formulations. These formulations being bulky poses several logistic problems besides the maintenance of shelf life. Novel delivery methods like seat coating and biocapsules have been developed tested and transferred to entrepreneurs at ICAR- Indian Institute of Spices Research, Kozhikode. In seed coating the beneficial microbes are delivered on the seeds and as the seedling emerges it gets the benefit of microbial colonization. This was tested for seed spices and demonstrated in farmers field. Farmers were able to record 20-30% enhanced yield besides reduced soil borne diseases. In the Biocapsule technology, the volume is reduced by one hundred times as in place of 1kg talcum formulation a mere ten capsules can be used. This paper discusses the success of this technology.

I.05: Perspectives and challenges of plant growth promoting rhizobacteria application for crop improvement- A case study

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Plant growth promoting rhizobacteria (PGPR) comprised of a wide range of root colonizing bacteria have the capacity to enhance plant growth and reduce intensity of plant diseases by suppressing the growth of deleterious rhizosphere microorganisms or by inducing systemic resistance. The complexity of the soil ecosystem is a constraint that makes biological control of the root pathogens by introduced antagonists a challenge. A study was conducted to explore the phosphate solubilizing bacteria is more suitable for the management of tomato disease. Vascular wilt caused by *Fusarium oxysporum* f.sp. *lycopersici* (Sacc.) is an important disease of tomato and occurs throughout the world. The fungus may cause great loss to tomato, depending upon the tomato cultivar and the environmental conditions. Currently many fungicides such as, benomyl, thiram, thiabendazole and carbendazim are used to manage the wilt fungus. But these fungicides adversely affect the useful soil microorganisms and environment. The application of PGPR especially phosphate solubilizing bacteria which is applied as seed treatment, soil amendment and spray treatment against Fusarium wilt of tomato will reduce the disease incidence to a greater extent and also increase the germination and planting value. Application of phosphate solubilizing indole acetic acid producing rhizobacteria, is more suitable compared to PSRB and IRB to improve plant health of tomato. Applications of control tomato wilt pathogen and also increase the yield and planting value.

Technical Session III

Regional Initiatives and Priorities of Plant Health for Research and Development

L.02: New approaches in plant health management: A case study

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Crop disease management in India has come a long way since the practices of "Uproot and Burn". Though the basic principles of disease management have not been altered the context of their use has undergone changes. The basic principles of crop protection such as; of quarantine, sanitation or eradiation, chemical or biological control and host resistance has not changed but the way these are practiced today with the use of diagnostics, detection and monitoring has been quite different. Similarly, quantum adoption of these techniques are influenced by the emerging concerns of pollution, biosafety, environmental safety, ecology, economics and even sociology. The highest technological change that is seen currently is the way of developing disease resistant cultivars. The methods have undergone several beneficial changes and reduced the time gap for releasing the cultivars for cultivation. The influence of biotechnology and genetic engineering on the development of resistant cultivars is highly visible. Bt cotton is an excellent case study to understand as to how an intractable pest problem has been solved through the tools of genetic engineering. Bt cotton success is being replicated in several crops where there are intractable problems of pests, diseases, weed, quality, input use efficiency and others like drought, and salinity exists. Similarly, the success of molecular assisted breeding which has benefitted rice to combat the dreaded bacterial blight disease in India is extended to many crops like corn, wheat, soybean, cotton, vegetables and many others for managing specific disease problems. The tools of producing GM crops are also being improved and now it may be possible to address the concerns of biosafety and environment without the help of regulatory mechanisms. It is therefore necessary for Plant Pathologists to get acquainted with the latest technological developments in all related sciences.

Technical Session IVA

Knowledge Management, Outreach and Commercialization

L.05: Coordination among phytopathological societies for quality improvement

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Professional societies devoted to the discipline of plant pathology came in to being, in India, with establishment of first society, the Indian Phytopathological Society in 1947. Subsequently, four more plant pathological societies, which can be counted upon, have come up in the country. It is evident that all these societies have similar objectives like providing forum for fellow scientists for personal interaction through holding national and international symposia, scientific meetings, disseminating professional information through publication of newsletters and research journals, instituting awards and memorial lectures, encouraging young scientists and recognising the contribution of teachers and researchers involved in plant pathological endeavours, identifying gaps and providing directions to make the discipline more vibrant, relevant and futuristic. They identify and promote talent, academic interest and excellence. Most of these societies have been regularly holding annual meetings, brain storming sessions, national conferences and symposia on important themes and special symposia on important topics. In addition, some of them are also periodically organising Asian and international conferences. The recommendations emerged from various conferences have also been helpful for policy planning and formulation of strategies for management of serious and threatening plant diseases from time to time. Multiplicity of professional societies vis-a-vis publication of number of research journals with overlapping mandates has however not enhanced the quality of publications which is evident that none of the journals published by these societies is having respectably high NAAS rating. Some of the journals have not qualified even for the UGC list of approved journals of the subject. Resultantly, quality output from certain reputed laboratories is being preferred to be published in journals published from other countries due to their better standing and rating. Large number of regional meetings/symposia with overlapping dates and common membership usually witness thin attendance and end up without logical conclusions / recommendations from casual deliberations. The matter has attained serious concern as to how to enhance the quality and rating of the journals. It is also thought that scattered efforts should be consolidated to harness benefit of expansion and qualitative research. It was a welcome initiative to establish a Federation of Phytopathological Societies of India some time back which needs to be revived and strengthened with extended and committed membership of societies. The Federation can be an excellent guiding force to carry out introspection, negotiation with various bodies, scientific audit, coordinate and channelize the efforts by formulating yearly, short term and long term plans to harness synergy of different societies without disturbing the individual identity and functioning as per their respective constitution. The pros and cons will be discussed to generate judicious opinion.

I.01: Commercialization of *Trichoderma* spp. and other bio-agents for management of stresses in crops vis –a- vis for prosperity of developing nations

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Biological agents viz. fungi, bacteria, viruses, etc. are a part of the biological niche and play an important role in the ecology of agro-ecosystems. Bio-agents *viz., Trichoderma viride, T harzianum, Pseudomonas fluorescens*, *Bacillus subtilis,* etc. have been found quite beneficial for sustainable and eco-friendly management of biotic stresses viz. seed and soil borne diseases of crops particularly wilt (*Fusarium* spp.), root rot (*M. phaseolina*, & *R. solani*), collar rot (*A. niger*), stem rot (*S. rolfsii*), etc. which may cause huge quantitative and qualitative yield losses in crops. The bio-agents are also useful to plants to promote plant growth and root development, induce systemic resistance (ISR), manage the abiotic stresses viz. extreme temperatures, drought, salinity, allelopathic effects, oxidative stress, etc. Besides bio-control, *Trichoderma* spp. have been found to decompose organic matters with its powerful enzymes *i.e.* chitinases, cellulases, proteases, ß-1,3- glucanases and dissolve phosphorus to make available of the nutrients for plant health. Use of bio-agents in consortium formulations along with mycorrhiza and bio-fertilizers can alleviate not only extrinsic stresses, but intrinsic stresses as well. Seed treatments with *Trichoderma* spp. can restore vigor and improve germination. The use of biological agents in agriculture to manage soil and plant health is the present day need for eco-friendly management of plant diseases and for sustainable crop productivity, reduction of cost of cultivation and remunerative return of agricultural produce. The mass production technologies of the bio-agents have been developed. Commercial production of the bio-agents for the management of the diseases has now emerged as a potential sector for employment generation, where millions of skilled persons will be required at different levels by the year 2020 particularly in developing world, where unemployment among the youths are the emerging problem. Being a Sun rising sector, the funding agencies need to support SAU's, NGO's financially in the form of projects to train the farmers, entrepreneurs, NGO's, SHGs, extension agencies, etc. The farmers will gain hands on training in the production process & develop need based commercial products of the bio-agents through solid and liquid fermentation technologies. The bio-agents are useful to manage the biotic and abiotic stresses of plants, help reduction in cost of cultivation of crops, improving the health of soil and plants, help in generation of employment for its production and commercialization, etc, and thus will prove to be one of the best sector for improving socio-economic condition of farmers of developing nations and thereby help the nations to become prosperous and self-reliance.

Technical Session V

Eco-friendly approaches for Soil and Plant Health Management

L.03: Plant disease management with ecofriendly biopesticides

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During last decade, species of *Trichoderma* have emerged as most powerful bioprotectants for management of wide variety of plant diseases. This is more true in the context of the fact that there is considerable public pressure and pressure from environmental scientists to reduce emphasis on chemical protectants and use bioprotectants. The genus *Trichoderma* by virtue of its broad spectrum action against a number of plant diseases caused by fungi, bacteria, viruses and even nematodes has occupied the top position among the bioprotectants developed for plant disease management. *Trichoderma* based biopesticides have been proved successful in a large number of field, vegetable, fruit and flowering crops for the management of diseases. Because of its eco-friendly nature and low cost when compared with chemical protectants, the technology has been very widely adapted all over the world. The literature accumulated on the subject during last decade is quite vast. *Trichoderma* strains exert biocontrol against phytopathogens either indirectly by competing for nutrients and space, modifying the environmental conditions, or promoting plant growth and plant defensive mechanisms and antibiosis or directly by mechanisms such as mycoparasitism. These indirect and direct mechanisms may act coordinately and their importance in the biocontrol process depends on the *Trichoderma* strain, the antagonized fungus, the crop plant, and the environmental conditions, including nutrient availability, pH, temperature, moisture and iron concentrations. *Trichoderma* species are plant symbiont opportunistic virulent organisms, able to colonize plant root by mechanisms similar to those of mycorrhizal fungi. Root colonization by *Trichoderma* species frequently enhances root growth and development, crop productivity, resistance to abiotic stress and the uptake and use of nutrients. Root-fungus association also stimulate plant defensive mechanisms. *Trichoderma* added directly to rhizosphere or as seed treatment protects plant against numerous classes of pathogens, e.g. those that produce aerial infections, including fungal, bacterial, nematodes and viral pathogens. This reveals induction of resistance mechanisms similar to the hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR) in plants. The low cost technology has opened up a new vista for plant disease management and is likely to be a boon for seed industries who would like to provide protection to seeds as well as plants against a large number of seed, soil- borne and foliar diseases.

L.04: Strategies for biomanagement of *Fusariam* wilt of banana

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Banana is an important food and one of export fruits from many tropical countries. This is an affordable food/dessert for millions in the developing countries. It is widely cultivated but has a serious Wilt disease, caused by *Fusarium oxyspoum* f. sp. *cubense* (Foc). It is a limiting factor for growth of the crop. Since the day of search of *Fusarium* causing wilt in banana, many control measures, like fumigation of soil, crop rotation along with organic amendments have been attempted. But the problem could not be resolved fully except by planting the resistant cultivars or starting with tissue cultured plants. However, use of resistant varieties alone is not sufficient to be implemented in field due to lack of consumer preference. Due to these problems, use of biocontrol agents gained importance. Bioagents having potential to protect and promote plant growth by colonizing and multiplying both in rhizosphere and plant system. They are useful as an effective alternative to varieties/chemicals for managing the banana wilt. Biocontrol of banana wilt is now gaining popularity being eco-friendly, having a potential to create new mechanisms or strategies for the crop protection. *Trichoderma* spp., acts as an interactive agent in root, soil and foliar environments by releasing an array of bioactive compounds, with localized effect or systemic resistance responses in the treated plants. *Pseudomonas* spp. also have the potential towards control of phytopathogens through release of a wide range of antagonistic metabolites. Treatment with bioagents per acre is very economical than chemical and is ecofriendly. The presentation would comparatively deal with different biocontrol agents/strategies found effective against *Fusarium* wilt of banana on field.

I.03: Management of bacterial wilt of tomato incited by *Ralstonia solanacearum* through bacterial antagonists

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Bacterial wilt of tomato caused by *Ralstonia solanacearum* (Smith) Yabuuchi is one of the most devastating, spreading worldwide and affecting 54 botanical families and 450 plant species. In India, *R. solanacearum* race 1 biovar 3 is dominated mostly in coastal and hilly and foot hill area of India and causes very heavy losses varying from 2-90% in tomato. The pathogen produces wilt symptoms first on leaves, and then the whole plant may be wilted rapidly. The vascular tissue of the stem shows a brown discoluration and if the stem is cut crosswise, drops of white or yellowish bacterial slime exude from the vascular tissue. The pathogen is spread via soil, in which it survives for varying periods of time and irrigation water. Biological control of bacterial wilt of tomato crops through antagonistic bacteria is an alternative approach to reduce disease incidence. Several bacterial antagonists such as *Actinomycetes* sp., *Azotobactor chroococum, Bacillus cereus, B. coagulans, B. subtilis, B. megatarium, B. pumilus, B. licheniformis, B. vallismortis, Enterobacter aerogenes, E. cloacae, Paenibacillus polymixa, Pseudomonas aeruginosa, P. fluorescens, P. glumae, P. putida, Streptomyces corchorusii, S. mutabilic,* avirulent strain of *R. solanacearum*, Hrp- mutant of *R. solanacearum* are generally used for control the disease. Species of antagonistic bacteria such as *Bacillus, Pseudomonas* and *Pantoea* were isolated from rhizosphere of tomato and characterized them by using morphological, colony characters, biochemical test and 16S rRNA sequences analysis. Based on the grouping of bacteria, both the strains DSBS-4 and DSBS-5 showed maximum similarity (>99%) with *Bacillus subtilis* whereas, strain DTPF-2 belongs to *P. koreensis* and DTPF-3 belong to *P. fluorescens*. In case of bio-efficacy of these strains of antagonistic bacteria, minimum wilt intensity (46.0%) in tomato cv. Pusa Ruby was found by treating with *P. fluorescens* DTPF-3 followed by *B. subtilis* DTBS-5 under glasshouse conditions. The *P. fluorescens* DTPF-3 showed significantly better wilt disease control than the *B. subtilis* under this condition. Integrated approach for management of bacterial wilt by treating with bacterial antagonists and chemical bleaching powder**,** minimum bacterial wilt intensity was found in bleaching powder (0.01%) + *B. subtilis* DTBS-5 treatment in both cultivars *i.e.* Arka Abha (19%) and Pusa Ruby (29.6%). *Pantoea agglomerans* was also found effective to control wilt disease of tomato under glasshouse conditions. In field experiment treated by seedling deep with mixed and alone application of bioagents in tomato plants, minimum wilt disease intensity 22.13% was recorded in combination with *P. fluorescens* DTPF-3 + *Trichoderma harzianum* Th3 with highest biological control efficacy followed by *P. fluorescens* DTPF-3 (28.73) alone as compared to control 48.80%. The disease incidence may be reduced further, if it is integrated with resistant cultivars of tomato.

I.06: *Trichoderma* as biological control agent for integrated disease management and healthier soil and plant for sustainable agriculture

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Disease management by using biological control agents attracted more attention due to development of resistant strains of phyto-pathogens against chemicals, adverse effects of non-judicious application of fungicides leading to outbreaks of new diseases and environment pollution. Among the various types of biological control agents, *Trichoderma* species were found to be effective against large number of plant pathogens. *Trichoderma* is having high reproductive capacity, ability to survive under adverse conditions, efficiency in the utilization of nutrients, capacity to modify the rhizosphere, strong aggressiveness against plant pathogens and efficiency in promoting plant growth and defense mechanism. The *Trichoderma* spp. alone and in combination with fungicides proved effective against several plant diseases and being considered as a major component of integrated disease management. The isolates of *T. viride, T. harzianum* and *T. virens* proved highly effective against several plant pathogens. The novel seed dressing bio-formulation Pusa 5SD and soil application bio-formulation Pusa Bio-pellet 10G were developed from the potential isolate of *T. harzianum* with longer shelf life. Both the formulations alone and in combinations were found effective against several diseases of pulse crops, vegetables and rice. It increased seed emergence by providing protection to germinating seeds in the soil, as a growth promoter enhanced shoot and root lengths of treated plants and increased grain yield under field conditions. Seed dressing formulation showed superiority over recommended fungicides for seed treatment in respect of increasing seed germination, enhancing plant vigour and grain yield and reducing disease incidence. The formulations were compatible with various fungicides and insecticides as well as compatible with other beneficial microorganisms. The efficacy of Pusa 5SD was validated against diseases at different locations across the country. A combination of seed treatment with thiamethoxam, carboxin and Pusa 5SD (*T. virens*) followed by combined foliar sprays of thiamethoxam and carbendazim at 21 and 35 days after sowing produced the highest seed germination and grain yield in mungbean with the lowest intensities of cercospora leaf spots and mungbean yellow mosaic, and moderate incidence of wet root rot. Application of *Trichoderma* not only suppresses the disease development but also provides strength to the plants by improving their immunity and vegetative development. They also significantly influence microbial populations in rhizosphere soil, which accelerate the nutrient uptake and vigour of root biomass including plants. Ultimately, they improved the soil health, which is directly corresponded to the plant health and vigour and leads to the higher yield contributing sustainable development in agriculture.

I.07: Endophytic fungal bioagents in plant disease management

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Endophytes that colonize the plants internal tissues are ubiquitous in nature and known to occur in all plant species which generally belong to a fungi or bacterium. The major interest with endophytes is that they produce active secondary metabolites which have antimicrobial properties. Secondary metabolites produced by endophytes (in stems, leaves and roots) are mainly used for their survival purpose against abiotic and biotic stress. It also helps in disease resistance, water preservation and improved quantity of biomass. Endophytes occupy ecological niches in the living internal tissues of their hosts without any adverse effects. The ascomyceteous fungal genus *Trichoderma* (Teleomorph: *Hypocrea*) is a well-known antagonist and widely used biological control agent (BCA) against several economically important plant pathogens. It is also playing vital role in the industrial application for production of hydrolytic enzymes *viz*., cellulase, chitinase and glucanase. *Trichoderma* as endophytes have been reported in *Hevea* sp. with *T. amazonicum*, cocoa with *T. martia*, *T. hamatum* and *T. asperellum*, coffee with *T. flagellatum*, Lentil with *T. gamsii* and *Dendrobium nobile* with *T. chlorosporum*. Endophytism of *Trichoderma* in different crops needs to be investigated in depth for better understanding its mechanism against biotic and abiotic stresses since Trichoderma is commonly used in the form of seed and soil treatment. There are studies where opportunistic endophytism of *Trichoderma* spp. in Pusa Basmati-1 (PB-1) variety of rice has been reported after their introduction through seed and soil. More light needs to be shed in understanding the interaction between the entophytes, host plant and pathogen. This will bring scientist to better explore good management practices for plant diseases. It is worth to explore the possibility to commercialize bio fungicide products based on endophytic *Trichoderma* since there are no similar products in the market at present. Other possible areas of research are the practical application of phytoremediation by endophytic *Trichoderma* and its ability in biodegradation. It is also worthwhile to explore role of endophytic *Trichoderma* in bioremediation, research needs to be conducted on their adaptabilities to adapt to polluted environments as well as investigate their remediation performance.

O.10: Phyto-mediated recovery of soil health

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Modernization has become an integral part of society and a lot of new younger cities is proliferating across the globe which is necessary for the economic development of the people. As a result of unprecedented colonization, the agricultural soil has become contaminated. Soil pollution as part of land degradation is caused by the presence of XenoBionis (human-made) chemicals or may be caused by industrial activity, agricultural chemicals, or improper disposal of waste. Soil Management can be accomplished by growing various different species of plants; keeping the soil covered by living plants as much as possible, soil contamination has become a major problem now-a-days especially in India and other developing countries. It not only affects the productivity of the crops but also creates a toxicological risk for its potential consumers.

Technical Session VI

Quarantine, Diagnosis, Taxonomy and Biodiversity

I.09: Diagnosis and management of plant health using new information and communication technology

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Disease diagnosis in field is mainly based on the characteristics symptoms (necrotic, hypoplastic and hyper plastic), signs and syndrome produced by different plant pathogens and host pathogen interactions. However, in laboratory a lot many molecular and diagnostic tools are now available to detect and diagnose a variety of plant diseases. The management of plant diseases depends mainly in its correct diagnosis. Plant health diagnosis and management strategies to combat these diseases are regularly provided to the farmers of Chhattisgarh by 25 KVKs of IGKV working under our guidance and close supervision. Agricultural extension services now need to assume new challenges and reform itself in terms of content, approach, structure and processes. We have to provide a range of agricultural advisory services including plant protection and facilitate application of new knowledge of plant diseases/insect pests. A strong, vibrant and responsive extension system with an expanded mandate is a pre-requisite for achieving a faster, sustainable and more inclusive growth through intensive agriculture. Farmers currently need a wider range of support, including organisational, marketing, technological, financial and entrepreneurial. Farmers require a wide range of knowledge from different sources and support to integrate these different bits of knowledge in their production context. These challenges for effective plant health management may be achieved through input agencies (dealing with seeds, fertilisers, pesticides, equipments), large agri-business firms (involved in manufacture and sale of inputs and purchase of farm produce), farmer organisations and producer co-operatives, non-governmental organisations (NGOs), media (print, radio and television) and web based knowledge providers, financial agencies involved in rural credit delivery, and consultancy services. The most commonly used low cost ICT individual and social media tools having huge potential to deliver relevant and actionable informations to farmers in time for crop health management are Mobile, Smartphone, Mobile voice calling, Video calling, Messaging, Facebook, Twitter, Whatsapp, Telegram, e-mailare, Instagram and You tube. The new ICT tools which are now widely adapted by the extension personnel in rural areas are the use of plateforms like low cost videos by *Digital Green* for agricultural extension, web portals (Kisan portal, Krishi Gyan portal, KVK portal), Mobile Apps (e-Crop Doctor*),* Agri Daksh (Expert System for different Crops), Mushroom AGRI Daksh*,* Gramin Krishi Mausam Sewa project (GKMS)*,* Skymet Weather app*,* AgroStar Farmer App (A "direct-to-farmer" technology platform), Network of smart phones, Community radio services at KVKs and Colleges etc. The voice phone calling assisted whatsapp for photograph of infested/infected crop from farmer's side and identification and prescription from scientist/subject matter specialist through whatsapp was found to be more efficient and cheapest way of managing plant health and providing other agro-advisory services in shortest period of time (5-10 minutes). The reach of extension personnel (field functionaries, rural youth and farmers) in rural areas (around 1200-1500 farmers/RAEO) can increase manifolds with the use of ICT plateforms. It has proven to be a wonderful tool to extension professionals for sharing information and to be a part of discussions, debates on extension, enhances capacity development, and integrating in delivering content in different formats for self learning of the target groups.

I.21: Current research on diagnosis and management of citrus greening disease in India

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Citrus greening (Huanglongbing / HLB) is a devastating disease of citrus which is associated with the phloem limited, Gram negative bacterium *Candidatus* Liberibacter asiaticus (*C*Las). The pathogen is not cultured on artificial media yet, therefore its taxonomical classification is based on the 16S rRNA gene sequence instead of traditional methods such as morphology, growth, enzymatic activity. It is grouped into alpha subdivision of proteobacteria, genus *Candidatus* Liberibacter in the family *Rhizobiaceae*. It is transmitted by the Asian citrus psyllid (ACP) vector, *Diaphorina citri* (Kuwayama). The insect vector is heat resistant and can withstand high temperature but sensitive to high rainfall and humidity. The typical symptom of the disease is yellowing of leaves along the veins and blotchy mottling which most of the times resembles to zinc and iron deficiency symptoms. The disease mainly diagnosed through symptom expression, biological indexing and different PCR based molecular diagnostic tools. 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. The disease was diagnosed through symptom expression, biological indexing and different PCR based molecular diagnostic tools. Different sets of greening bacterium-specific primers were designed and synthesized for amplification of 16S rDNA, 16S/23S intergenic regions, ribosomal protein genes and *omp* genes. A multitude of PCR based techniques *viz.*, PCR, multiplex PCR, real time PCR, LAMP based diagnostic tools etc have been developed and are now being used routinely for detection of *Candidatus* Liberibacter asiaticus in citrus plant samples as well as their potential insect vectors either singly or as mixed infection. All the infected samples yielded specific amplification products, sizes of which were found similar to that amplified from '*Ca.* Liberibacter asiaticus'. Again, part of the genomes of this bacterium infecting citrus have been cloned, sequenced and their phylogenetic and evolutionary relationships has been established. 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 of China and USA. Standardized molecular diagnostic tools can be successfully utilized to implement citrus bud wood certification program to develop certified disease-free planting material. However, effective and economical management of this bacterium and such other systemic pathogens infecting a vegetatively propagated important fruit crop like citrus are likely to be developed based on integrated strategies involving host resistance to the pathogen(s) and vectors.

I.18: Novel approaches for rapid virus detection of plant viruses: A case study of banana viruses

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Banana is one of the most important fruit crop of India and is being commonly cultivated through tissue culture. The current production of banana through tissue culture is around 500 million plantlets per annum. Four major viruses known to naturally infect bananas are *Banana bunchy top virus* (BBTV), *Banana streak virus* (BSV), *Banana bract mosaic virus* (BBrMV) and *Cucumber mosaic virus* (CMV). Of these viruses, BBTV and BSV are DNA viruses while, BBrMV and CMV are RNA viruses. Banana is a vegetatively propagated crop and the viruses infecting banana are transmitted by the vegetative planting material like suckers, bits and corms. Tissue culture banana production technology ensures supply of disease free quality planting material to the farmers. Virus indexing in banana is mainly done through immuno-based (Enzyme linked immunosorbent assay, ELISA) and nucleo-based (Polymerase chain reaction, PCR) techniques. ELISA is one of the most commonly used serological method for detection of RNA viruses in banana. A significant advancement has been made in the serological techniques in the form of lateral flow immunoassay, a rapid user friendly dip stick/strip method that has been successfully applied for on-site detection of CMV and BBTV. The current molecular methods for detection viruses in banana include standard PCR, reverse transcription PCR (RT-PCR) and real time PCR. Further, techniques like immunocapture PCR (IC-PCR) and rolling circle amplification (RCA) have been developed for detection of BSV and BBTV. Simultaneous detection of DNA and RNA banana viruses have also been carried out using duplex and multiplex PCR/RT-PCR. Apart from conventional PCR methods, rapid and simple isothermal amplification techniques have been explored for virus detection in banana. Loop mediated isothermal amplification has been successfully applied for detection of both DNA and RNA banana viruses. Recombinase polymerase amplification (RPA) is another rapid and simple technique used for speedy amplification of nucleic acids in limited resource/laboratory settings. Recently, gel-based RPA assay has been successfully developed for detection of BBTV in different banana cultivars. An attempt has also been made for rapid detection of CMV using fluorescence based real-time isothermal reverse transcription-recombinase polymerase amplification assay.

I.14: Role of quarantine in biosecurity against plant viral diseases in Asia-Pacific: Challenges

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Plant viral diseases are known to cause serious yield losses. There are several instances of inadvertent introduction of viruses along with introduced planting material into a country. Trade and exchange of germplasm at international level play a key role in the long-distance dissemination of a destructive virus or its virulent strain. The worldwide distribution of many economically important viruses is attributed to the unrestricted exchange of seed lots. Of the material being imported, bulk imports for sowing/ planting carry maximum risk as thorough examination becomes difficult and planting area required is also too large. Quarantine processing is often restricted to smaller samples derived from them and based on results of these samples the whole consignment is rejected/ detained or released. Certain small samples meant for research purposes especially germplasm or wild relatives of a crop are more likely to carry diverse biotypes/ races/ strains of the pest and are of immense quarantine importance. The challenges in virus detection in quarantine include availability of antisera, viral genome sequences in Genbank, detecting an unknown/ exotic virus etc. Also strengthening of infrastructure, capabilities and methodologies for detection of viruses in bulk samples is essential. During the last two decades, at ICAR-NBPGR, adopting a workable strategy, using techniques ranging from biological to molecular, a large number of viruses including 19 viruses: *Barley stripe mosaic virus*, *Bean mild mosaic virus, Bean pod mottle virus*, *Broad bean mottle virus, Broad bean stain virus, Broad bean true mosaic virus*, *Cherry leaf roll virus*, *Cowpea mottle virus, Cowpea severe mosaic virus,* Dioscorea latent virus, *Garlic virus C*, High plains virus, *Maize chlorotic mottle virus*, *Pea enation mosaic virus*, *Peanut sunt virus*, *Pepino mosaic virus, Raspberry ringspot virus, Tomato ringspot virus* and *Wheat streak mosaic virus* not reported and 21 viruses not known to occur on particular host(s) in India have been intercepted. The introduction of 19 exotic viruses was averted. The pest risk analysis revealed absence/ presence of viruses in certain countries in Asia-Pacific region which necessitates the quarantine for preventing transboundary movement of viruses in Asia-Pacific region. Establishment of a *Asia-Pacific Diagnostic Network for Plant Viruses* would be the backbone for strengthening the programme on biosecurity. Also *Asia-Pacific Regional Working Group of Experts for Detection and Identification of Plant Viruses* need to be formed to explore cooperation in terms of sharing of expertise and facilities. This would help in avoiding the introduction of plant viruses not known in the region and also the movement of plant viruses within the region.

I.16: Minimizing risk of introduction of exotic pathogens associated with import of plant genetic resources into India

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Plant genetic resources (PGR) is an important source for their utilization in breeding programme for developing new varieties resistant to biotic/abiotic stresses or high yielding varieties for food security. ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi is the nodal agency for introduction of exotic PGR including transgenics for research purpose in India after quarantine clearance. Quarantine examination involves testing of seed and other planting materials which always carry an inadvertent risk of introduction of exotic pathogens or their more virulent races into new areas as evident from several examples of destructive pathogens getting entry into new areas along with the introduction of planting material such as *Phytophthora infestans* (late blight of potato) from Central America (Peru) to Ireland in 1845, *Unicinula necator* and *Plasmopara viticola* (powdery and downy mildews of grapes) from Central America to France in 1847, *Urocystis agropyri* (flag smut of wheat) from Australia to Mexico, *Cryphonectria parasitica* (chestnut blight) from orient countries including Japan and Korea to USA, *Hemileia vastatrix* (coffee rust) from Sri Lanka to India in 1875, *Tilletia indica* (Karnal bunt of wheat) from India to USA in 1996, etc. leading to profound economic and social consequences in the past. In order to broaden genetic base of crops, ICAR-NBPGR imports every year ~100,000 samples including germplasm, international trials and transgenic material for research use both by public and private sector. Critical quarantine examinations of importing materials result in interception of a large number of exotic pathogenic fungi on various crops from different parts of the world. The interceptions included *Calviceps purpuria* in *Triticum aestivum*, *Fusarium oxysporum* f. sp. *cucumerinum* in *Cucumis sativus*, *Monographella nivalis* in *Triticum aestivum*, *Peronospora manshurica* in *Glycine max*, *Phomopsis longicolla* in *Helianthus annuus*, *Uromyces beticola* in *Beta vulgaris* (not reported from India); *Bipolaris maydis, Puccinia carthami* in *Carthamus* spp., *Puccinia helianthi* in *Helianthus* spp. (have different races); *Botrytis cinerea, Fusarium oxysporum* and *Fusarium solani*, *Rhizoctonia solani*, *Macrophomina phaseolina, Sclerotinia sclerotiorum* in a variety of hosts (have wide host range); *Leptosphearia maculans* in *Brassica* spp., *Tilletia barclayana* in *Oryza sativa* (have limited distribution), etc. of quarantine significance to India. Interception of large number of pathogens of quarantine significance on a wide range of crops from different countries emphasizes the pivotal role of plant quarantine in minimizing risk of introduction of exotic pathogens associated with PGR importing into the country, otherwise huge losses would have occurred due to exotic pathogens/diseases.

O.08: Exploration of undiscovered fungi of Meghalaya State of North East Region of India

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Meghalaya state is the most wet region of India known for rich fungal diversity. Therefore, survey was conducted in four unexplored hill districts of Meghalaya Ri-Bhoi, namely East Khasi Hills, West Khasi Hills and Jaintia Hills during 2015 and 2017 respectively. More than 93 diseased plant samples and 222 soil samples were collected to investigate the possibility of diverse group of fungal associations. Three hundred and four fungal isolates were cultured and were identified based on macro and microscopic characters. The morphological (cultural and microscopic) characters revealed that these fungi belong to 41 genera and 58 species of Ascomycetes, Basidiomycetes and Zygomycetes. Majority of the fungi obtained were Ascomycetes which includes *Alternaria*, *Aspergillus, Arthrobotryts, Bipolaris, Chaloropsis, Chaetomium, Cladosporium, Colletotrichum, Curvularia, Fusarium, Macrophomina*, *Metarhizium*, *Myrothecium*, *Nigrospora*, *Paecilomyces*, *Penicillium*, *Pestalotiopsis*, *Phoma*, *Phomopsis*, *Talaromyces, Trichoderma* and *Stachybotrys*. The genera of Zygomycetes obtained were *Absidia, Basidiobolus, Cunninghamella*, *Gongronella, Mucor* and *Rhizopus*. The genera of Basidiomycetes were *Daedalea, Hapalopilus, Irpex, Sterium, Coltricia*, *Coreolus**,** Daedaleopsis, Echinodontium, Heterobasidium, Lenzites*, *Polyporus, Schizophyllum* and *Trametes.* Out of these fungi, few were reported for the first time from this region. The identification of some fungi were confirmed through molecular analysis. The diseased specimens were deposited at Herbarium Cryptogamae Indiae Orientalis (HCIO) and identified fungal cultures at Indian Type Culture Collection (ITCC), Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi and their HCIO and ITCC accession numbers were obtained.

O.25: Identification, characterization and detection of viruses associated with orchids in Sikkim and Darjeeling hills of West Bengal

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India is the natural home of more than 1300 species of orchids, of which 800 species are found in North-eastern region. Orchids are the largest and most diverse group of flowering plants. Over the years, Sikkim and Darjeeling hills have emerged as important centres of orchid production as the climatic conditions prevalent in these hills are most suitable for growing orchids particularly cymbidium hybrids. Virus diseases are serious threat to orchid industry as they not only reduce the general vigor of the plant but also lower the flower quality. More than 50 viruses are known to infect orchids all over the world but in India only 10 viruses are recorded so far on cultivated orchids. Important virus diseases reported from India are Cymbidium mosaic virus (CymMV), Odontoglossum ringspot virus (ORSV), Calanthe mild mosaic virus (CalMMV), Orchid fleck virus (OFV), Groundnut bud necrosis virus (GBNV), Vanilla necrosis virus (VNV) and Vanilla mosaic virus (VMV). Besides, cucumber mosaic virus (CMV), Cymbidium ringspot virus (CyRSV) and bean yellow mosaic virus (BYMV) has also been reported on some orchid species. Among them, CymMV and ORSV are economically the most important viruses and are widely distributed on all commercial hybrids and germplasm collection. Attempts have been made to develop both serological and nucleic acid based detection of these viruses for production of virus free planting material. Polyclonal antibodies against CymMV and ORSV have been developed using bacterially expressed CP as immunogens. DAC-ELISA have been standardized and widely used for the detection of CymMV and ORSV from planting material. ELISA and RT-PCR based detection of CymMV, ORSV, CalMMV, GBNV has been standardized. Duplex RT-PCR protocol for the simultaneous detection of CymMV and ORSV has also been demonstrated. These diagnostics will be highly useful for the production of virus free planting material of orchids.

O.05: Genomic features of an Indian isolate of rice false smut pathogen *Ustilaginoidea virens*

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Rice crop under field condition is affected by many fungal diseases. Among the diseases, false smut disease caused by *Ustilaginoidea virens* (Cooke) Takah was first reported from India and presently occurring in all rice growing regions worldwide. In recent years the disease is becoming very significant as it reduces the grain yield and quality due to discoloration of grains and it also has potential health hazards to human and animals due to the production of many toxins in the infected grains. Due its minority status, previous studies were mainly focused on disease occurrence, pathogen detection and pathogen life cycle however; reports on pathogenomics are limited. There are only two reports (From China and Japan) are available on pathogenomics and no reports are available from India. Therefore, a detailed investigation was undertaken to characterize the genomic features of Indian isolate UV-Gvt. False smut balls from the infected rice cultivar BPT5204 were collected and associated pathogen, *U. virens* was isolated. Pure culture of the pathogen strain UV-Gvt was obtained by sub culturing a single germinating chlymadospore. Pathogenicity was established by artificially inoculating the pathogen to rice cultivar BPT-5204. Pathogen was mass multiplied and mycelial-spore suspension was harvested after incubation at 25°C for 15 days. Genomic DNA was isolated using CTAB method. The paired end sequencing library was prepared using TruSeq Nano DNA Library Prep Kit (Illumina) and the size selected product was amplified with index primers. Library was subjected to paired end sequencing in Illumina NextSeq 500 platform it yielded approx 10 million high quality reads which showed more than 90% alignment to the previously sequenced *U. virens* genome from China (JHTR00000000). The Whole-Genome Shotgun project for *U. virens* strain UV-gvt has been deposited in DDBJ/EMBL/GenBank under the accession number PGGP00000000. Total of 8376 genes were annotated. PHIbase database search identified 2166 genes involved in the host-pathogen interaction. Fourteen effector proteins involved in the host modification during disease development were also identified, among them; six are unique to the UV-Gvt genome. As to the best of our knowledge, this is the first report of complete genome sequencing and annotation of *U. virens* from India.

I.15: Fungal endophytes: A treasure trove of biodiversity, host security, antimicrobial and myconanotechnology

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Fungi are a group of microbes which have been the important source of bioactive compounds since long back in addition to great diversity. Overall, it has been estimated that only about 6-8% of fungal species are yet known, and in this regard 'fungal endophytes' are being considered as a new and alternative source of diversity and bioactive products. Natural bioactive compounds produced by endophytic fungi are having new mechanism of action within the cellular metabolism, and thus we explored fungal endophytes of *Azadirachta indica*, *Aegle marmelos*, *Tectona grandis*, *Madhuca longifolia* etc., and found new bioactive compounds with interesting results. Some interesting fungal genera isolated from these hosts were *Alternaria, Aspergillus, Cladosporium, Choridium, Curvularia, Drechslera, Fusarium, Gliomastix, Nigrospora, Periconia, Pestalotiopsis, Phoma, Phomopsis, Stenella, Trichoderma, Verticillium* including Mycelia-Sterilia. For isolating the improved and cryptic metabolites finally, *Colletotrichum gloeosporioides* was selected and treated with different doses (1 µM, 10, 50, 100, 500 µM) of epigenetic modulators such as sodium butyrate and 5-azacytidin separately and in combination, respectively. Results showed the improved (2 folds) metabolites production including some cryptic ones with increased antibacterial activity against control. The biosynthesis of metal nanoparticles (NPs) using fungi is considered as a unique and eco-friendly method as it is free from any solvent or toxic chemical, capping agents and also easily amenable to large-scale production. The fungal isolates *Aspergillus clavatus*, *A. terreus, Phoma herbarum, Phomopsis helianthes, Chaetomium globosum and Trichoderma viride* were used for biosynthesis of silver and gold nanoprticles using aqueous solution of silver nitrate (AgNO3), and tetra auro chlorate (HAuCl4), respectively. *Aspergillus clavatus* and *C. globosum* induced AgNps were antimicrobial in nature. UV-VIS spectroscopy, transmission electron microscopy (TEM), Atomic force microscopy (AFM), FTIR and X-ray diffraction (XRD) were used to characterize the NPs.

O.09: *Bipolaris* - *Curvularia* - *Cochliobolus* Complex – their phylogenetic and taxonomic re-evaluation and DNA barcoding

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Bipolaris, Cochliobolus and *Curvularia* form a complex of plant pathogens on many crop plants. The morpho-taxonomy of these genera is confusing because there is no clear morphological boundary and some species of these genera show intermediate morphology. Frequent nomenclatural changes have occurred due to refinements. An attempt was made for authentic identification of different species of *Bipolaris* and *Curvularia* using combined morphological and molecular data. Twenty isolates of *Bipolaris* and 52 isolates of *Curvularia* were obtained from different culture collection centres of India. Additional 12 isolates of *Curvularia* were collected from soil and plant samples collected from different parts of Delhi-NCR region. All the isolates were characterized based on cultural and conidial characters. Molecular identification using internal transcribed spacer (ITS) region sequences was done based on NCBI database. Five species of *Bipolaris viz*., *B. hawaiiensis*, *B. maydis*, *B. oryzae, B. sorokiniana* and *B. spicifera* and 16 species of *Curvularia viz*., *C. aeria, C. affinis, C. australiensis, C. borreriae, C. catenulata, C. clavata, C. eragrostidis, C. geniculata, C. inaequalis, C. lunata, C. pallescens, C. prasadii, C. specifera, C. trifolli, C. tuberculate* and *C. verruculosa* were confirmed through combined morphological and molecular data. The phylogenetic relationship among *Curvularia, Bipolaris* (imperfect stages) and *Cochliobolus* spp. (perfect stage of both the genera) was analysed using ITS region sequences obtained from NCBI database. *Curvularia* and *Bipolaris* formed clear clusters and the species of *Cochliobolus* were clustered along with the respective anamorphic (*Curvularia* and *Bipolaris*) species. Therefore, *Cochliobolus* can be considered as the perfect state of both the genera. Three species of *Bipolaris viz*., *B*. *australiensis*, *B*. *hawaiiensis* and *B*. s*picifera* clustered with *Cuvularia* along with their teleomophic (*Cochliobolus*) species. Therefore, these species are transferred and named as *C. australiensis, C. hawaiiensis* and *C. spicefera* and it is the first report from India. ITS, β-tubulin, LSU, SSU and *tef-1* regions for *Bipolaris* and ITS, GPDH, LSU, SSU and *tef-1*for *Curvularia* were analysed separately using five species of *Bipolaris* and sixteen species of *Curvularia* to select the potential region for DNA barcode for authentic identification. Based on barcode gap and probability of correct identification, ITS was selected as potential barcode and better marker for *Bipolaris* and *Curvularia* species identification which is also reported as a universal barcode. The sequences were submitted in the BOLD and the DNA barcodes were obtained.

O.26: Mycorrhizal diversity of weed species in degraded and deficient land ecosystems

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Study area of Naldurg is located at 17.82°N 76.3°E in Osmanabad district of Marathwada region in Maharashtra state, India. This area lacks natural resources and is prone to drought, rocky and dry with low and uncertain rainfall. Roots and rhizosphere soils of weed plant species were collected in *rabi* and *kharif* season during 2015-2016 from degraded land and assessment of Arbuscular Mycorrhizal Fungi (AMF) root colonization, spore density and spore diversity was calculated. Altogether 21 species belonging to 11 families and 21 genera in *rabi* season and 20 weed species belonging to 9 families and 20 genera in *kharif* season were collected and examined diversity and AMF status. Percent AMF root colonization was ranged from 40.62-84.37%. The highest colonization was recorded in *Phyllanthus niruri* (84.37%) and least in C*occulus hirsutus* (40.62%) in *rabi* season. In case of *kharif*, percent root colonization ranged from 43.75-81%. The highest colonization was recorded in *Dichanthium caricosum* (81%) and least in *Adenostemum alavenia* (40.62%). Vesicular, arbuscular and hyphal types of root colonization was recorded in both the seasons. Seven of the 11 common plant species showed higher root colonization in *rabi* season as compared to *kharif*. AM fungal spore density varied in all weed species and ranged from112–1168 spores/100g soil in rabi while 237–702/100g soil *kharif* season. In all, six species of AM fungi were identified. These include *Acaulospora rehmii, Glomus macrocarpum, G. microaggregatum, G. delicata*, *G. geosporum* and *Sclerocystis* sp. *Acaulospora, Glomus* and *Sclerocystis* species were dominant in both the season. In seasonal variation, AM spore density was greater in the *rabi* season than *kharif.* A positive correlation was found between AM fungal infections in weed plants.

O.03: Avirulence gene based profiling of *Magnaporthe oryzae* field isolates from South India and virulence analysis of rice blast isolates on monogenic lines

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Magnaporthe oryzae is one of the most devastating fungal pathogen causing blast disease in rice worldwide. The interaction between rice-*M. oryzae* follows Gene for Gene hypothesis. Understanding the avirulence gene distribution in *M. oryzae* population is essential for breeding stable resistant varieties. In the present study, 97 field isolates of *M. oryzae* collected from diverse rice ecologies of Southern India was analysed for the presence of eight avirulence genes using gene specific markers. Few isolates were devoid of any of the avirulence genes analysed in this study. *Avr-ACE1* cognate to *Pi33* gene in rice was present in highest frequency (76.28%) in tested isolates. *Avr-Pia* and *Avr-Pii* were present in very low frequency of 26.80% and 14.43%, respectively. Frequency of other Avr genes in the isolates varied: *Avr-Piz-t* (53.60%), *Avr-Pita* (46.87%) and *Avr-Pi9* (48.45%). Eight isolates possessed all the eight Avr genes, while the isolate Mo-si-206 carried only *Avr-Pi9* gene. The presence/absence polymorphism of Avr genes in the isolates was well correlated with the results of virulence analysis on the monogenic lines carrying cognate R gene. Sequence variation for *Avr Pi9* in the coding region was analysed in representative isolates and it was found that there was no sequence variation among the tested isolates for *AVRPi9* coding sequence. However, the isolates contained many transposable elements on chromosome 7 where *AVRPi9* locus is situated. Considering the highest distribution of *Avr-ACE1* in *M. oryzae* isolates, we here in propose to pyramid *Pi33* gene along with other *Pi* genes in elite rice varieties for durable blast resistance in future.

Technical Session VI

Plant Health Management - Case Studies

I.10: Wheat blast disease - A recent danger to South Asia's wheat production and our preparedness

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Wheat blast caused by the fungus *Magnaporthe oryzae* pathotype *Triticum* (MoT), is reportedly a new disease of wheat originated in 1985 in Parana State of Brazil and later identified in neighboring South American countries *viz.* Bolivia, Uruguay, Paraguay and Argentina. It has affected >3 mha and caused losses of 10-100% that depends on genotype, year, environment & planting date. Thus, it has been reported to be a cause of serious setback to wheat production of South America. In Princeton, Kentucky (USA), this disease was reported in 2011, but *Magnaporthe oryzae* pathotype Lolium (MoL) was later confirmed as a causing agent. South Asia particularly Bangladesh has witnessed the first occurrence of this disease outside South America during Feb-2016. A vast area of around 15000 ha in eight Bangladesh's districts of Meherpur, Kushtia, Chuadanga, Jheneidah, Jessore, Pabna, Barisal and Bhola faced severe crop losses. Average yield loss in affected field was 25-30%, while in severely infected plot 100% loss was also observed. Wheat blast again appeared in Jan-2017 with low severity, but additionally spread to four more new districts *viz.* Rajshahi, Faridpur, Magura and Khulna. Overall disease affected 22 ha area with average yield losses of 5-10% which was comparatively less from 2016 incidence. Though currently wheat blast is not present in India, this disease is glaringly posing a serious threat to food security in the neighboring South Asian countries sharing borders with Bangladesh due to recent outbreaks here. To prevent the probable entry of wheat blast disease into India from Bangladesh and South American countries, strategies have been jointly formulated by the DAC&FW, Government of India, ICAR, SAUs and State Department of Agriculture. To deal with any emergency situation an adhoc IPM program for wheat blast has already been designed. As a precautionary measure, "No Wheat Zone" up to 5 km distance from Bangladesh borders in India is already being maintained and "Wheat Holiday" is declared in two major wheat growing districts *viz.* Nadia and Murshidabad of West Bengal. Along with this, wheat growing areas near Indo-Bangladesh borders in West Bengal & Assam and West Bengal borders in Jharkhand and Bihar are being regularly surveyed and monitored by vigilant teams constituted by ICAR-IIWBR. To identify any presence of disease, trap plots nurseries are also established at planned locations in West Bengal which are frequently monitored by the team. To restrict the entry and import of wheat seeds from blast endemic regions (Bangladesh and South American countries) several strict quarantine measures are being followed. Indian wheat varieties and advanced lines were evaluated for their resistance against blast pathogen in Bangladesh, USA and Bolivia. Some of the entries like HD 2967 growing in North Eastern and Western Plains Zones were found considerably resistant. To create awareness among growers, officials of state department of agriculture and KVKs about the disease, various awareness drives, training program etc. are being organized and digital media platform is thrustfully used to propagate the message. Breeding programs for developing blast resistance in the Indian context has already been taken up by the scientist in tandem with other initiatives like deputation of Indian Scientist to Bolivia & Bangladesh for skilling them in advance techniques to combat this pathogen.

O.01: Current status of Cotton leaf curl begomovirus complex in India: disease incidence, genomics, virus distribution and molecular basis pathogenecity

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Cotton leaf curl disease (CLCuD), caused by whitefly transmitted monopartite begomoviruses with association of beta- and alpha-satellites, is a serious constraint for cultivation of cotton in the Northwest (NW) Indian states of Haryana, Punjab and Rajasthan. CLCuD was surveyed for the last 6 successive years from 2012 to 2017. Overall disease incidences were 37.5, 63.6, 38.8, 56.1, 44.8 and 58.6% in 2012 to 2017, respectively. The disease was higher of 77.5 in Haryana followed by 59.2% in Rajasthan and 54.1% in Punjab in 2013. Complete genomes of 13 CLCuD associated begomovirus isolates were amplified through RCA, cloned, sequenced and characterized. Based on sequence analysis, eight present CLCuD begomoviruses are members of Rajasthan (Ra), one of Faislabad (Fai) and another of Pakistan (PK) strain of *Cotton leaf curl Multan virus* (CLCuMuV); and five are members of Burewala (Bu) strain of *Cotton leaf curl Kokhran virus* (CLCuKoV). But CLCuMuV-Ra is detected as a predominant strain in NW India. Ten present begomoviruses were detected as recombinants, where CLCuMuV-Ra strain is strong recombinant. Complete genome of 19 beta- and 21 alpha-satellites associated with CLCuD were amplified, sequenced and analysed. The present betasatellites are members of Cotton leaf curl Multan betasatellite (CLCuMB) and all were recombinants. Four 4 species of alphasatellites, GDarSLA, CLCuMA, CLCuBuA and CrYVMoA were identified. The present study demonstrated that the complex interaction of recombinant CLCuMuV-Ra strain, recombinant betasatellite CLCuMB and divergent alphasatellites is associated with CLCuD outbreak in NW India. Two infectious clones (DNAA-A), 1.4 mer tandem repeat ofCLCuMuV-S-11 (pCAMBIA+S-11) and CLCuKoV-IARI-45 (pCAMBIA+IARI-45); two infectious clone of betasatellite (dimer), S-11B (pCAMBIA+S-11B) and IARI-30B (pCAMBIA+IARI 30B) associated with CLCuMuV- S-11 and CLCuKoV-IARI-30, respectively were constructed and agromobilized. The infectivity of these clones was studied in cotton and tobacco plants. No symptoms were observed in cotton and tobacco plants agoroinoculated with DNA-A construct alone but accumulation of DNA-A was detected. When DNA-A construct was co-inoculated with the betasatellite the construct produced symptoms.

O.02: Management of wheat streak mosaic virus, an emerging disease of the wheat

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Wheat streak mosaic virus (WSMV) causes wheat streak mosaic, a disease of cereals and grasses that threatens wheat production worldwide. It is a monopartite, positive-sense, single-stranded RNA virus and the type member of the genus Tritimovirus in the family Potyviridae. The only known vector is the wheat curl mite (WCM, *Aceria tosichella*), recently identified as a species complex of biotypes differing in virus transmission. WSMV also transmitted by seed in low rates (up to 1.5%). Infected plants are stunted and have a yellow mosaic of parallel discontinuous streaks on the leaves. In the autumn, WCMs move from WSMV-infected volunteer wheat and other grass hosts to newly emerged wheat and transmit the virus which survives the winter within the plant, and the mites survive as eggs, larvae, nymphs or adults in the crown and leaf sheaths. In the spring/summer, the mites move from the maturing wheat crop to volunteer wheat and other grass hosts and transmit WSMV, and onto newly emerged wheat in the fall to which they transmit the virus, completing the disease cycle. Three types of WSMV are recognized: A (Mexico), B (Europe, Russia, Asia) and D (USA, Argentina, Brazil, Australia, Turkey, Canada). WSMV has a wide host range, at least 10 species of cereals and 42 species of wild grass are reported as host so far. The grasses serve as one of the important natural reservoirs of the virus and there is a virus genome (CP gene) variation between grass and cereal hosts. The management of the virus is using Wsm2 gene-based cultivars are not effective due to their instability at high temperature. The most effective strategy for the management of WSMV is to use cultural practices such as i) avoiding early planting of winter wheat, in areas with high infection pressure of viruses to escape migrations of the mite from volunteer wheat or grasses to crops, ii) control grass weeds in cereals, which are hosts for the virus and mites through tillage or with herbicide, iii) planting a variety with resistance (if available) to the virus or vector, iv) limiting minimization technologies in corn growing in areas with a greater incidence of viruses, v) controlling grasses and grassy weeds around the borders of recently sown crops, vi) breaking the disease cycle by controlling summer cereal volunteers (the 'green bridge') to reduce the number of mites that can invade the following autumn sown crop. The work was supported by grants QJ1530373 and MZE RO0417.

O.07: Eco-friendly management of banded leaf and sheath blight of maize

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Maize is cultivated throughout the year in India for various purposes including grain, fodder, green cobs, sweet corn, pop corn, baby corn etc. Ubiquitous incidence of diseases in the pre-harvest stage is a major factor adversely affecting maize productivity. Among these biotic factors, banded leaf and sheath blight (BLSB) disease is most prevalent in south-east Asian countries, is caused by a soil born pathogen *Rhizoctonia solani* f. sp. *sasakii* (Kuhn) Exner. Maximum crop damage occurs when the fungus infects the cobs. Management of BLSB through chemical is the mainstay till date. Alternative management strategies are needed for management of BLSB for rising environmental, ecological and health concerns due to over use of chemicals in plant disease management, for which employment of organic molecules can be a viable alternative. Present investigation was carried out to check the efficacy of two bioformulations *viz.*, Pusa Th3 (*Trichoderma harzianum*) and Pusa Cg2 (*Chaetomium globosum*) against BLSB in the Vivek QPM-9 cultivar under *in vivo* conditions during *kharif* 2016 and 2017. Seven treatments *viz.,* Seed treatment (ST) with Th3 @2g/kg; Foliar spray (FS) with Th3 @2g/l; Both ST and FS with Th3*;* ST with Cg2 @2g/kg; FS with Cg2 @2g/l; Both ST and FS with Cg2 and FS with validamycin @2.7ml/l were tested. All the treatments significantly reduced the disease and contributed higher yield of maize as compared to positive check. The combination of seed treatment and foliar spray of both bioformulations were highly effective in suppressing BLSB disease. However, Pusa Th3 was superior to Pusa Cg2 with respect to grain yield.

I.19: Biochemical and molecular basis of chemically induced defense activation in maize against banded leaf and sheath blight disease

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Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani* f. sp. *sasakii* is a major disease of maize. The disease can be managed by using a combination of different management strategies at some level. Of which chemical approach is comparatively an effective strategy. But use of resistant varieties is preferred most as an eco-friendly and cheapest approach of disease management. Unfortunately, no true genetic sources of BLSB resistance are available in maize. Hence chemically induced resistance in the host plant is considered as an alternative strategy against many fungal diseases. Same strategy has been adopted in the present study and investigated the basis of BLSB resistance in maize hybrid variety Vivek QPM-9 applying fungicides at recommended dosages and two plant defense inducers *viz.*, salicylic acid (SA) and jasmonic acid (JA) at 50 and 100 ppm. The activity of antioxidant enzymes like superoxide dismutase (SOD) was high in Validamycin, Azoxystrobin and Hexaconazole. Catalase (CAT) and *β*-1, 3-glucanase activities were high in Azoxystrobin, Validamycin and Tebuconazole whereas peroxidase (POX) activity was high in Azoxystrobin, Validamycin and Trifloxystrobin + Tebuconazole. Polyphenol oxidase (PPO) activity was high in Validamycin, Azoxystrobin and Carbendazim. Similarly, phenylalanine ammonia lyase (PAL) was high in Validamycin, Azoxystrobin and Trifloxystrobin + Tebuconazole. Both plant defense inducers elevated SOD, CAT and PAL activities in maize at higher concentration. Expression of defense related genes after seed priming with SA and JA was determined by qRT-PCR. SOD, PPO and APX genes were down-regulated at lower concentration of SA, but CAT and *β*-1, 3-glucanase genes were up-regulated. In case of JA, expression of CAT and APX genes was up-regulated at lower dose whereas PPO and *β*-1, 3-glucanase genes were up-regulated at higher dose. SOD gene was down-regulated at both the dosage of JA.

O.06: Status of major diseases of Makhana in Koshi region of Bihar and correlation of weather parameters with alternaria leaf blight and spot

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Makhana (*Euryale ferox*) also known as foxnut, or gorgon nut is the oldest shallow aquatic cash crop. It is of great value due to its nutritional, medicinal and ritualistic significance. Bihar is the leading state of Makhana production, which accounts for more than 80% production in the country. A survey was conducted in three blocks of each district namely Saharsa, Supaul, Madhepura and Purnea during full cropping period (March to August) in consecutive year, 2017 and 2018. Maximum incidence of both alternaria leaf blight (20.32%) and leaf spot (16.42%) was recorded during second week of June at Nauhatta block of Saharsa district. Highest incidence of tumor or gall was recorded at Raniganj block of Purnea (10-12%) and Kishanpur block of Supaul (8-10%) during second week of July. However, the occurrence of Botrytis grey mould was found minimum which was around 5-7% in every district. Survey showed that *Alternaia alternata* and *A. tenuissima*, air borne pathogens, causing leaf blight and spot respectively, appears every year with varying intensity and render heavy reduction in the yield of nut. A field experiment was also conducted at research farm, MBAC, Agwanpur, Saharsa during year (2017 and 2018) with references to weather parameters, to know its effect on the incidence of leaf blight and spot disease. High temperature (31^{o}C) and relative humidity (>80%) correlated with higher incidence of alternaria leaf blight and leaf spot disease. Effect of rainfall on the incidence of disease was also studied and congenial conditions were manifested. On the basis of congenial mean temperature, mean relative humidity and average rainfall a geopahytopathological model for the prediction of alternaria leaf blight and spot disease has been developed.

O.04: Alternaria disease - an emerging problem of litchi (*Litchi chinensis*) in India

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India is one of the leading litchi (*Litchi chinensis* Sonn.) producing countries in the world. As compared to many fruit bearing trees, litchi is less affected by diseases in India. However, since 2014, *Alternaria alternata* (Fr.) Keissler has emerged as the most important pathogen of litchi causing disease at three phase *viz.*, leaf blight on nursery plants and orchard trees in vegetative phase, panicle or inflorescence blight and fruit blight in reproductive phase, and fruit rots at post-harvest. It was first noticed during 2012 on nursery plants causing leaf blight, the symptoms of which started from tip of the leaf as light brown to dark brown necrosis that advanced towards both the margins of the leaf leading to complete necrosis of the affected leaves. In orchard trees, it causes leaf blight similar to nursery stage, and at reproductive phase blighting of panicle and fruits occurs that was first noticed during April-June, 2014. At post-harvest stage, it remains as a dominant pathogen causing fruit decay. Over the years, the mean incidence of leaf blight on nursery plants was 22.2 to 50.3% while severity (PDI) ranged from 32.2 to 83.3. Disease incidence of panicle blight (on tree basis) in different orchards was 6.3 to 77.1% in cv. 'Shahi' and 17.0-58.9% in cv. 'China'. However, the maximum numbers of trees were having less than 20% blighted panicles. Primary inoculums come from senescing leaves of lower canopy, and leaf litters on which conidia can remain viable throughout the year. Comparatively large sized conidia that are highly resistant to UV radiation float in the air enabling long distance dispersal. The analysis of prevailing weather conditions over the year vis-à-vis disease revealed that a temperature of about 28-30°C and humidity 60 to 85% are congenial for panicle and fruit blights disease. The disease severity was more between Tmin 20-22°C and Tmax 32-35°C. In India, the development of litchi fruit usually coincided with rising atmospheric temperature (35-40°C) and low relative humidity (<40%) that were non-conducive for disease development. Though, *A. alternata* is a hardy pathogen and can live in extreme conditions, climate change in recent past, with a shift towards more cloudy weather and intermittent rains during reproductive phase of litchi that decrease temperature and increase humidity, has apparently aggravated the damaging potential and losses caused by this disease.

I.20: Harnessing the potentiality of bio-inoculants for disease management and soil health

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In today's world of chemicalization in agriculture, farmers aim to take more and more advantage of resource they have. This excessive external input in agriculture has initiated the era of intensive agriculture. Indeed Green revolution have enabled farmers to be self dependent, but in recent time the unlawful use of chemical fertilizers and pesticides are making the soil unproductive and ultimately hindering the ecological equilibrium. Today's demand for sustainable agriculture requires soil health management and pathogen management for raising the production of crops and fulfilling the requirements of growing Indian population. Conventional methods of soil health management require higher monetary inputs. Thus, it's time to impart bio-intensive agriculture in practice, employing the resident microbes of soil to make it healthy and suppressive (black box approach). However, soils where diseases have been prevalent can also restore their suppressive properties and promote growth of plants if provided with pathogen suppressing strains of microbes and probiotics (silver bullet approach). Management of diseases and soil health through bio-inoculants is going to play a prodigious role in establishing green economy. At present only few effective micro-organisms have been registered as biopesticide and formulations developed so far are dominated by *Trichoderma* sp, *Pseudomonas* sp and *Bacillus* sp. Shelf life and spuriosity of formulations available in market is of global concern and thereafter the illiteracy and unawareness about use of bio-inoculants among the end-users play role as restricting factors. Ultimately, leaving potential entrepreneurs and industries behind to explore effective microbial strain in the laboratory freezers. Indeed the government has intervened and understood the ill effects of excessive chemicalization in agriculture, thus promoting quality production and use of biofertilizers but yet the popularization and availibity to the doorstep of end user is at very slow pace. Industries must provide standard biopesticides in harmonization with international regulations to produce and supply high quality biopesticides. The complex ecological interactions between plant-soil-microorganisms in agriculture are not yet fully understood therefore it is a need for continued research into soil microbial diversity to maintain the health of this essential and critical resource. Awareness, utilization and technology if deployed appropriately, biopesticides have potential to bring sustainability to global agriculture for food and feed security.

I.22: Mitigating drought stress in rice using *Trichoderma harzianum*

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India is the second largest producer and consumer of rice, a staple human food at global level. Drought is one of the major factors contributing to severe yield loss in most of the crops grown in marginal lands and in rainfed areas. Use of bio-agents such as drought tolerant *Trichoderma* spp. seems to be an effective and easy to adapt strategy to mitigate the drought effects in rice. In various plants, *Trichoderma* species are primarily being used for their ability to control diseases, plant growth promotion and tolerance to abiotic stresses including drought. Among the several mechanisms employed by *Trichoderma* to enhance drought tolerance, the most studied mechanism relates to *Trichoderma* is, induced plant growth promotion including enhanced nutrient uptake and inhibition of deleterious root microflora. Its strains were applied to rice through seed bio-priming. Bioprimed seed were sown in the pots containing soil and different parameters related to drought tolerance were measured. Rice seed biopriming with *T. harizianum* strains resulted in enhancing root and shoot length and biomass of rice plants. Chlorophyll content, leaf area and flag leaf area were also increased due to bioprimming with these microorganisms. Presence of relative water content is the indication of overall water content available in the plant system and plant tissues. More the relative water content in plant cells, related tissues will show more stress tolerace, whereas presence of less relative water content in the plants indicates less stress tolerance. Rice seed treated with the different strains of *T. harzianum* expressed less reduction in relative water content as compared to untreated check. In the stress conditions, the reduction in membrane stability index is always higher; however seed treatment with different strains of *T. harzianum* resulted in enhancement of membrane stability index. This is an indication of drought tolerance. Presence of proline is another very important biochemical indicator which is directly related with the capability of a plant for drought tolerance. It was noticed that accumulation of proline in the plant tissues get increased when plant were exposed to water deficit conditions, which indicates that there is less water content in plant which is always detrimental for plant health especially in drought. However, results indicated that seed treatment with *T. harzianum* resulted in less accumulation of proline content means providing more space for water retention in plant tissues which ultimately manifested in providing tolerance to drought stress. All these biochemical mechanisms have been investigated and discussed in detail.

O.21: Combined effects of soil salinity and some agrochemicals on growth of *Rhizobia*

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Agrochemicals such as fungicides, herbicides, insecticides and antibiotics are used to control many crop diseases, but use of such agrochemicals are most important and potentially limiting factors to Biological Nitrogen Fixation. Herbicides used to leguminous crops causes potential danger to the establishment and N_2 forming performance of root nodules. In the present investigation 51 isolates of *Rhizobia* were isolated from *Crotalaria pallida* Ait., *C. verrucosa* L., *C. retusa* L., *Clitoria ternatea* L., *Vigna anguiculata* (L.) Walp subsp. cylindrica (L.), *Vigna mungo* (L.) Hepper and *Mimosa pudica* L. from south west coast of Maharashtra and screened for their salinity tolerance. Out of 51 isolates, 48 isolates of *Rhizobia* were resistant to sodium chloride and seven isolates were highly resistant to NaCl and tolerated upto 8% NaCl. To study combined effect of agrochemicals on the development of salt tolerance in *Rhizobia*, they were grown in YEM broth containing 8% NaCl with fungicides (Kocide 101, Redomil, Benofit, Blitax, Roko, Bavistin and Kavach), herbicides (Dhanuka Dhanuzine, Sencor, Matin, Krizin, Mera-71 and Atrazin), insecticides (Krinet, Prime, Sharp and Monosaan) and antibiotics (Nalidixic acid, Norfloxacin and Cefotaxime) all at 10 to 100 µg/ml. There was nearly 99-100% inhibition of NaCl resistant *Rhizobia* isolates due to combined effect of NaCl and above mentioned agrochemicals.

O.22: Studies on black rot of cabbage caused by *Xanthomonas campestris* pv. *campestris*

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Vegetables constitute a substantial part of human diet supplying vitamins and minerals. Among large number of vegetables, cabbage (*Brassica oleracea*) is one of the important vegetables consumed throughout the world because of its health improving constituents like minerals and vitamins A, B1, B2 and C. Cabbage cultivation encounters various disease problems including black rot caused by X*anthomonas campestris* pv. *campestris* (Pammel, 1895 and Patwardhan, 1982). Considering the magnitude of the disease and its resultant losses, an investigation was undertaken on this disease to bring out appropriate management practices. The experiments were carried out during *kharif* 2015-16 in the field of the Department of Plant Pathology, College of Agriculture, and in the farmers' field. The bacterium was isolated from infected leaves with typical symtoms of black rot collected from major cabbage growing areas of northern Karnataka, yielded yellow, mucoid, shiny, slimly, convex and odorless colonies on nutrient agar and yeast extract dextrose calcium carbonate agar. Based on the biochemical and morphological characteristics, the bacterium was identified as *X. campestris* pv. *campestris.* The isolated bacterium evaluated for pathologenicity by different methods in pot culture study. Among all, carboraundum abrasion method found best in symptom expression and lesion progress and the control inoculated with media has shown small chlorotic areas on the leaf lamina. In case of integrated disease management with chemicals like bactericides, bio agents and combinations, seed treatment with K-cycline (0.5 g) + Copper oxychloride (3.0 g) and first foliar spray with K-cycline (0.5 g) + Copper oxychloride (3.0 g) and second foliar spray with *Pseudomonas fluorescens* (10.0 g). effectively suppressed the disease incidence and recorded minimum per cent disease index, high yield and more cost : benifit ratio followed by seed treatment with K-cyclin (0.5 g) + Copper oxychloride (3.0 g) and two foliar sprays with K-cyclin (0.5 g) + Copper oxychloride (3.0 g).

O.24: XopC2 T3SS effector of *Xanthomonas axonopodis* pv. *punicae* suppresses pomegranate immune responses to support bacterial growth during blight development

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Xanthomonas axonopodis pv. *punicae* (Xap), the causal bacterium of pomegranate bacterial blight, is one of the major limiting factors of pomegranate cultivation worldwide including India. The disease appears in epiphytotic form every year leading to significant fruit damage and decrease in crop export. Xap depends on the TTSS-effectors to overcome the pomegranate innate immunity. Our previous studies revealed that Xap secretes 6 effectors, XopC2, XopE1, XopL, XopN, XopQ and XopZ. This study aimed to investigate the role of XopC2 during blight pathogenesis. We demonstrated that XopC2 is essential for Xap multiplication *in planta* and Xap-dependent suppression of immune responses, including PTI gene transcription, callose deposition, and ROS production. Leaves infected with the Xap *ΔxopC2* mutant produced restricted water-soaked lesions compared with those infected with wild type Xap. Consistent with these findings, we detected increased levels of PTI associated pomegranate transcripts in leaves challenged with Xap *ΔxopC2*. XopC2::EYFP fusion protein under transient expression was tracked to localize to the plasma membrane suggesting the possible site of its action. We also evident that XopC2 suppresses plant cell death (PCD) event in pomegranate, presumably to support Xap for its multiplication in the living plant tissues for sufficient period of time during pathogenesis. Altogether, this study indicates that XopC2 effector plays an important role in Xap virulence during blight development in pomegranate. Moreover, this insight into the molecular basis of XopC2 function as well as other Xap T3SS-effectors will provide new avenues to manage bacterial blight of pomegranate in the field.

O.27: Improvement of soil health through enriched spent mushroom substrate (SMS) and its effects on plant health, productivity and wilt incidence of tomato

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Cultivation of edible mushrooms also generated a large quantity of spent mushroom substrate (SMS) or compost. This is basically degraded organic or agro based material. The microbial flora present in the spent substrate have antagonistic effect on the soil borne pathogens. Spent mushroom substrate is a good source of nitrogen, phosphate, potassium and carbon and used effectively as ruminant feed. This spent substrate is also a good carrier for biocontrol agents and nitrogen fixing bacteria. Farm yard manure is a good source of organic material for earthworm. Spent mushroom substrate is also effectively bio-transformed into vermin-compost by the activity of earthworm. Spent mushroom based fertilizers are easily used up by the plants in both green house condition and field condition. The nitrogen fixing bacteria *Azotobacter*, *Azospirillum* and *Rhizobium* were grown well on spent mushroom substrate. Maximum height (66.3 cm), average shoot biomass (129g), average root biomass (33.3g) and yield (1.48 kg) of tomato plant was obtained from the SMS enriched with *Azotobacter* spp. + *Azospirillum* spp. (1:1) followed by the SMS enriched only with *Azotobacter* spp. Three well known bio-control agents (*Trichoderma viride*, *T. harzianum* and *P. fluorescens*) were mixed with the SMS for enriching the compost. The effects of the bio-control agents enriched SMS were assessed on tomato plant under natural environmental condition. SMS enriched with *P. fluorescens* and *T. viride* (1:1) showed maximum plant height (61 cm), shoot biomass (137g), root biomass (29g) and yield (1.15 kg) followed by the combination of *P. fluorescens* + *T. harzianum* (1:1) which exhibitted (59.7 cm), (132g), (28g) and (1.133kg) plant height, shoot biomass, root biomass and yield respectively over the untreated SMS (control). Application of vermi-compost prepared by the combination of spent mushroom substrate + FYM + *Azotobacter* spp. (1:1:0.01%) and earth worm *Eisenia foetida* in soil gave highest plant height 72 cm, maximum average dry shoot biomass/plant 136g, highest dry root biomass 43.67g and maximum yield 1.717 kg/plant of tomato followed by the vermi-compost prepared by the combination of SMS and FYM which gave 68 cm plant height, 130.33g of shoot biomass, 39g of root biomass and 1.550 kg/plant of fruit yield. The performance of SMS based vermi-compost were compared with others organic composts against wilt diseases of tomato. Among the different treatments, compost repaired with spent mushroom substrate + FYM + *Azotobacter* spp. (1:1:0.01%) and earth worm *Eisenia foetida* was found to be most effective in inhibiting the disease by 66.87% and gave a maximum plant height of 79.30 cm at 120 DAT, maximum average dry shoot biomass/plant of 145g, highest dry root biomass of 53.0 g and maximum yield of 1.85 kg/plant followed by Earth worm compost + FYM (1:1) which exhibited 62.58% reduction in disease, 73 cm plant height, maximum average dry shoot biomass/plant of 135g, highest dry root biomass of 46.0 g and maximum yield of 1.65 kg/plant. The present investigation would provide very useful information to the farmers for increasing the soil and crop health as well as to minimize the wilt incidence in field.

O.28: Correlation of weather parameters with development of *Alternaria* leaf blight of gerbera

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Gerbera (*Gerbera jamesonii*), the most popular cut flower crop is being marketed in the international cut flower industry and secures the fourth position globally. One of the important constraints that limit the production of quality flowers in gerbera is the severe incidence of fungal diseases. It is evident that plant diseases are always influenced by the interaction between host, pathogen and environment and the disease progresses due to an infectious pathogen as well as due to favourable host factors apart from weather parameters like temperature, relative humidity (RH), rainfall, number of rainy days and other epidemiological conditions. Hence, the present investigation was undertaken to study the *Alternaria* leaf blight disease of gerbera occurring in the state of Kerala during different seasons and correlate its occurrence with the 3 weather parameters *viz.,* temperature, RH and rainfall. For this, a purposive sampling survey was carried out in 3 districts of Kerala *viz.,* Wayanad, Malappuram and Thrissur during rainy, winter and summer season to observe the occurrence of *Alternaria* leaf blight disease. The samples showing typical symptoms of leaf blight disease were collected from gerbera grown both under polyhouses and in open field conditions. Pathogens were isolated from diseased leaf samples showing typical symptoms. Pathogenicity of the isolate was proved by artificial inoculation of cultures on healthy plants. Based on the cultural and morphological characters coupled with pathogenicity, etiology of the leaf blights were confirmed as *Alternaria alternata* and *Alternaria tenuissima.* During sampling survey, the extent of intensity (PDI) and severity (PDS) were recorded for the two *Alternaria* leaf blight diseases and correlated with the weather parameters. Among the leaf blights, leaf blight 1 (LB-1) was observed in all the 3 districts during 3 seasons whereas leaf blight 2 (LB-2) was confined only to Wayanad district, the high range zone of Kerala. In general, LB-1 disease showed positive correlation with temperature however, reverse relation existed with relative humidity and rainfall. PDI and PDS recorded were highest for LB-2 and the severity of the disease was found positively correlated with temperature whereas no significant relation was noticed with RH and rainfall during the disease development. Thus, gerbera grown with a lower temperature coupled with an above average RH and low rainfall may bring down the disease to some extent but at such a juncture the temperature plays the havoc as there will be sudden upsurge in temperature immediately after the wet spells.

Technical Session VIII

Plant Health Management – Research Trends

O.11: Integrated capability of supplementary agrochemicals on the growth of carbendazim resistant *Botrytis cinerea* causing leaf and flower blight of rose

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Rosa floribunda, Baker is infected by *Diplocarpon rosae* Wolf, *Sphaerotheca pannosa* Walworth ex Fers, *Alternaria alternata* (Fr.) Keissler, and *Botrytis cinerea* Pers., causing black spot, powdery mildew, leaf spot and leaf blight, respectively. Among all these fungal diseases, leaf blight caused by *Botrytis cinerea* is very common and serious threats to rose plantation. These diseases are managed by farmers following various management practices. Fungicides are most extensively used in countries having high agronomic technology. Four fertilizers, three herbicides and five different micronutrients were tested against the *B. cinerea* along with carbendazim. Among the fertilizers, Samarth and DAP reduced the growth of pathogen at 0.1% with 1000 µg/ml carbendazim, while urea and muriate of potash decreased the growth as the concentration goes on increasing. From tested herbicides, Kleen-80 and Krizin inhibited the growth of the pathogen at 50 µg/ml, while Atrazin inhibited the growth of the pathogen at 75µg/ml. Sencor reduced growth of the pathogen with its increased concentration in the Czapek Dox Agar medium. Among screened micronutrients, copper and zinc inhibited the growth of the pathogen at 0.1% with 1000 µg/ml carbendazim, while iron, manganese and cobalt reduced the growth with the increased concentrations.

O.12: Influence of biofertilizer and biocontrol agents on medicinal and aromatic plants

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There has been an increasing interest of populations worldwide towards herbal products and therefore, continuously growing demand for plant-based medicines in the international market. In order to combat the ever increasing demand of plant based health products, pharmaceuticals, food supplements, cosmetics etc., there must be an efficient commercial approach for cultivation of medicinal and aromatic plants (MAPs). Commercial cultivation of medicinal and aromatic plants is highly dependent on a number of critical factors like location, good genetically stable planting material, good agrotechnological practices, nutrient inputs, efficient pre and post harvesting techniques etc. Traditional agrotechnological practices sometimes limit in terms of profitability to the cultivars. Mycorrhizae fungal biofertilizers have been used to enhance the productivity of crops from ages. Vermicompost and other bioferilizers and biocontrol agents are also used for improved plant health and enhanced productivity. However, exploration and exploitation of these fertilizers are still not very common as far as medicinal and aromatic plants are concerned. It has been shown by various researchers that they have positive influence on the overall growth of the MAPs as well as the quantity of essential oils without changing the quality and chemical constituents. Present report will emphasise on the influence of various biofertilizer and biocontrol agents on the MAPs and its commercial impact on the society including cultivars as well as the buyers in international market.

O.23: Modelling of diseases of sunflower under changing climatic scenarios in southern Karnataka

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Sunflower is an important oilseed crop of India. Karnataka with the largest share in sunflower area is recognized as "Sunflower State" in the oilseeds scenario of the country. The major diseases of sunflower are necrosis virus, *Alternaria* blight, powdery mildew, rust, collar rot and downy mildew. Weather conditions play a predominant role in determining the course and severity of epidemics of a disease. Hence, present work was undertaken to study the influence of different weather parameters on infection and development of major diseases and secondly to develop forecasting model. Correlation values clearly indicated that necrosis and powdery mildew were not associated with any of the weather parameters individually. While, Maximum temperature had significant negative influence on Alternaria leaf blight severity ($r=0.664, \alpha=0.05$). The linear regression equations of individual weather parameters developed indicated that weather parameters individually had no significant effect. On the other hand, it is well known that weather parameter never occur individually. Hence, Multiple Linear Regression (MLR) equations were fit for all three diseases with set of all the weather parameters. The MLR developed for Necrosis was Y= -291.28+0.22RF-6.16RD+17.48TMax-4.77Tmin+0.18RH-15.50SSH, for Alternaria leaf blight was Y=1205.08 +0.28RF-9.93RD-91.75TMax+69.01TMin-0.28RH+30.43SSH and for powdery mildew was Y=-1032.73 -0.29RF+2.40RD+30.69Tmax+20.29Tmin-1.18RH-15.12SSH. ANOVA-F (1.331) of MLR developed for necrosis was found to be non-significant. Moderate R^2 (0.615) and multiple R (0.817) value indicates that though not significant still disease is influenced by weather parameters. RH when regressed individually had no significant influence while it was found to be the most significantly (at 5%) influencing weather parameter among the set of weather parameters for powdery mildew. Though not significant, collectively all weather parameters have moderate influence (R^2 = 0.668 & multiple R = 0.817) on powdery mildew. MLR developed for Alternaria leaf blight indicates that Maximum temperature is the most significantly (at 5%) & negatively influencing parameter among the set. Among 12 years, predicted disease percentage for Alternaria blight is in acceptable limits (deviation: -20 to +20%) in 6 years. From the above equations the severity of diseases can be predicted one/two weeks prior by considering mean earlier one week weekly observations of weather parameters. Long term correlation of weather factors with disease severity needs to be recorded for the development of appropriate forecasting model.

O.13: Management of leaf rust and insects of wheat by new pre-mix molecule

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Two years of field experiment was conducted during *rabi* 2011-12 and 2012-13 to manage leaf rust and some pests of wheat using fungicides and insecticides. The experiment was conducted in RBD with eleven treatments under restricted irrigation condition. The variety Amruth was used and all the pesticides were applied as seed treatment. Leaf rust was recorded on 35th DAS and termite, shoot fly and aphids were recorded on 30th and 40th DAS, respectively. Germination percentage in all the treatments recorded significantly better than untreated control. Maximum germination was recorded in the treatment RIL-071/F1 (20% FS) @ 2.0 ml/kg seed (92.2%) which was followed by its lower dose RIL-071/F1 (20% FS) @ 1.5 ml/kg seed (91.35%) and Tebuconazole 2% DS @ 1.0 g/kg seed. The control plot recorded the lowest germination of 74.5%. The treatment, Imidacloprid 18.5% + Hexaconazole 1.5%FS (RIL-071/F1 (20% FS) @ 2.0 ml/kg seed (9 ACI) provided significantly less leaf rust severity over other treatments except treatment RIL-071/F1 (20% FS) @ 1.5 ml/kg seed (13.00 ACI) and Tebuconazole 2% DS @ 1.0 g/kg seed (10.67ACI) which were on par with each other. The next best treatment was Hexaconazole 5% SC @ 0.60 ml/kg seed (13.67 ACI). The control plot recorded the rust severity of 41.67 ACI. The overall termite infestation was less in both the years. The population of termites was significantly less in all the insecticide treatments over others. However, in the treatment, RIL-071/F1 (20% FS) @ 2.0 ml/kg seed as well as with its lower dose of 1.5ml/kg seed and Imidacloprid 600 FS @ 0.77 and 0.58g/kg seed was nil. Over all aphid infestation was also less in both the years. The population of aphids was significantly less in all the insecticide treatments over others. However, in the treatments RIL-071/F1 (20% FS) @ 2.0 ml & 1.5 ml/kg seed, Imidacloprid 600 FS @ 0.77 & 0.58 g/kg seed the infestation was nil. All the insecticide treatments found superior to the other treatments in reducing the shoot fly incidence over the years. The grain yield was significantly superior in case of RIL-071/F1 (20% FS) @ 2.0 and 1.5 ml/kg seed. The treatment Imidacloprid 18.5% + Hexaconazole 1.5%FS (RIL-071/F1 (20% FS) @ 2.0 ml/kg seed recorded 11.64 q/ha of grain yield. The control plot recorded less yield of 6.28 q/ha. The natural enemy populations were not significantly varied in all the treatments including untreated check.

I.17: Role of endophytes in mitigating soilborne fungal diseases of groundnut

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Endophytes are the microorganisms that reside inside healthy plant tissues without causing any detectable disease symptoms to the host. Often, each and every plant harbors either one or more of endophytic microorganisms. The study of endophytes is now on a voyage of interest, not only because of their role in filling the divide between discovered and undiscovered microbial diversity, but also due to their harboring a great potential to produce novel natural products. Looking to the importance of endophytes, an attempt was made to isolate and evaluate the endophytes against soilborne diseases in groundnut and to study their mode of action. Total 106 fungal endophytes were isolated from different parts of groundnut *viz.,* leaves, stem and roots and 18 from *Ocimum* sp resulting in 124 endophytes. During *rabi*/summer 2016-17, 47 fungal endophytes were isolated from GPBD-4 and JL-24 genotypes and 59 fungal endophytes were isolated from different parts of northern Karnataka *viz*., Bagalakote (6), Belagavi (34), Dharwad (14) and Haveri (5). Among the genotypes, maximum number of endophytes were isolated from GPBD-4 at 15 days after sowing. The bio-efficacy of these endophytes was tested under *in vitro* and *in vivo* against soilborne pathogens like *Sclerotium rolfsii* (stem rot) and *Rhizoctonia solani* (root rot). Based on the *in vitro* studies, 12 endophytes were selected for *in vivo* studies. Among 12 fungal endophytes evaluated on plant growth parameters and bio-efficacy against two soilborne diseases, LFDwAc-7 recorded least disease incidence of stem rot (33.33%) and root rot (27.78%) and higher plant growth parameters like plant height, root length, number of leaflets, fresh and dry weight. The effective fungal endophytes were identified by morphological and molecular methods as *Nigrospora sphaerica* (LFDwAc-7), *N. chinensis*, *Fusarium equiseti*, *F. brachygibbosum*, *F. oxysporum, F. solani, Curvularia spicifera*, *Cu. Ausreliensis* and *Chaetomium globosum*. Among different methods of application of endophytes, plant height, root length, and number of leaflets were more in soil drenching method, where as fresh and dry weight was maximum in foliar spraying. Defense enzymes like peroxidase (PO), polyphenol oxidase (PPO) and phenylalanine ammonia lyase (PAL) activity was higher in endophyte + pathogen treated plants on 7th day after inoculation and endophyte *N. sphaerica* (LFDwAc- 7) recorded more of PO, PPO and PAL activity.

O.14: Arbuscular mycorrhizal fungal association in indigenous scented black rice (*Oryza sativa* L.) and effect of bioinoculants on its growth and yield in North Eastern India

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Knowledge about the occurrence and diversity of native arbuscular mycorrhizal fungi (AMF) associated with agricultural crops of a specific area is essential for utilizing them in any application. Therefore, we assessed the community composition of AMF in rhizosphere soil and their colonization patterns in the roots of indigenous scented black rice (*Oriza sativa* L. cv. Chakhao amubi; family Poaceae) during harvesting period under subtropical terrace cultivation system of Manipur, North Eastern (NE) India. A total of 9 AMF spore morphotypes belonging to six genera *viz.*, *Acaulospora*, *Funneliformis*, *Glomus*, *Rhizophagus*, *Sclerocystis* and *Scutellospora* were isolated from natural field and trap culture soils. Maximum relative abundance (%RA) and isolation frequency (%IF) were recorded with the spores of *Funneliformis mosseae* followed by *Acaulospora spinosa*. The examined root fragments revealed *Arum*-type AM morphology which is reported for the first time in cv. Chakhao amubi. The intensity of AM fungal colonization and distribution of different fungal structures in black rice roots varied significantly. Total root length colonization with AMF ranged from 46% to 62%. The percentage root length with hyphae varied between 21% and 37% and the vesicles from 4% to 5%, while the arbuscules ranged from 18% to 31%. Further, we evaluated the influence of 2 dominant AM fungi i.e. *A. spinosa* (*A.sp.*) and *F. mosseae* (*F.mo.*), individually and in combination with rhizobacteria i.e. *Azospirillum* sp. (*Azo.*), on the response of black rice cultivar cv. Chakhao amubi in pot conditions using non-sterilized field soil as substrate with seven different combinations of bioinoculants (C- Control; T1- *A.sp.*; T2- *F.mo.*, T3- *Azo.*; T4- *A.sp.* + *Azo*.; T5- *F.mo.* + *Azo*.; *T6- A.sp.* + *F.mo*. + *Azo.*). No microbial inoculum was added in control treatments. Maximum shoot length, number of leaves, shoot and root dry biomass, grain yield and root mycorrhizal colonization were observed in the rice plants which were inoculated with *F.mo. + Azo.* as compared to controls and other treatments. The rice plants inoculated with *F.mo. + Azo.* also had higher shoot and grain P content, however their uptake efficiency were not significantly different with other treatments. Thus, our results suggest that the application of indigenous AMF along with efficient bioinoculant during seedling transplantation increases the overall growth and yield performance of aromatic black rice and can be considered as potential bioagents for studied crop production in NE India.

O.15: Impact of bio-agents on blast, sheath blight, bacterial blight and drought tolerance in rice

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Investigation was carried out on effect of bio agents on diseases and drought stress with five *Trichoderma harzianum* isolates, of which three were collected from IRRI [T-14, 94 (A) and IRRI-2] and two were isolated from native soil by serial dilution method (OT-3 and OT-8). Their antifungal activities were determined *in vitro* by dual culture technique which revealed that all the three isolates collected from IRRI were superior to the native isolates in the order of 94(A), T-14 and IRRI-2. A pot culture experiment was conducted where *Trichoderma* isolates was applied as seed treatment @ 5 g per kg of seed before sowing and foliar spray with culture filtrate during tillering stage. Further the crop was challenged by artificial inoculation of *Pyricularia oryzae, Rhizoctonia solani, Xanthomonas oryzae* pv. *oryzae* and drought induction by withdrawing irrigation. Upon observation, Trichoderma isolate 94(A) treated plants recorded least disease incidence and enhanced grain yield followed by isolatesT-14, IRRI-2, OT-3 and OT-8. The interaction between plant and *Trichoderma* promotes plant growth, induces resistance to disease and drought. The tillering and the panicle initiation stages in the crop were advanced considerably in *Trichoderma* treated plants. Despite of all these advancement, the time taken for maturity remained unchanged. The intervention also influenced the total number of grains per panicle and total number of filled grains per panicle. Different bio-chemical parameters were tested to find the influence of *Trichoderma* in rice plant. The enzyme chitinase which is unanimously considered as a tool to strengthen plant immune response against various stresses was found more in *Trichoderma* treated plants over the control. The level of peroxidase which plays an important role in plants' biochemical defence against several pathogens also increased more in *Trichoderma* treated plants. Ascorbate peroxidase (APX) considered as a scavenger of hydrogen peroxide decreased significantly. Superoxide dismutase (SOD), an enzymatic antioxidant increased in *Trichoderma* treated plants. The oxidative chemicals like proline, malondialdehyde and hydrogen peroxide exhibited a decrease. The studies on biochemical characters also revealed an augmentation in phenol and cell membrane stability which are known to alleviate stresses due to disease and drought through various mechanisms. It can be concluded from the present study that *T. harzianum* renders multiple benefits to plant. Their benefits in reducing disease and drought stress have been demonstrated separately. Present study made a novel approach to manage two stresses with single intervention. The effect of *Trichoderma* on disease incidence, drought stress and yield demonstrated in the present experiment were correlated with morphological and biochemical characteristics which substantiated the findings. The use of different isolates and record of variations among them in rendering benefit is a new concept which should be further investigated.

O.16: Evaluation of resistant tomato germplasm against tomato yellow leaf curl disease to improve crop productivity in Oman

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Tomato yellow leaf curl disease (TYLCD) has become a major constrain for tomato (*Solanum lycopersicum*) production in Oman. The development of tomato lines with resistance against the begomoviruses (whitefly-transmitted virus of the genus *Begomovirus*, family *Geminiviridae*) that cause TYLCD has become an important target in tomato breeding programs worldwide. The study assessed fourteen tomato inbred lines in 2012/2013 and nine in 2016/2017 harbouring one or more of TYLCD resistance genes, and susceptible tomato entries for resistance against the TYLCD complex in Oman by screening in the field. The lines were evaluated for TYLCD incidence, severity and viral DNA titer in field trials conducted over two consecutive years. Additionally the identities of the virus and betasatellite in selected plants from each line were determined by cloning and sequencing. Overall, all *Ty* gene-containing lines performed better than the susceptible controls, with significantly lower incidence and disease severity as well as a significantly lower titer of viral DNA. Those lines harbouring either *Ty*-2 alone or in combination with other Ty genes showed the lowest levels of TYLCD resistance. The best performing line harboured *ty*-5 alone, displayed no symptoms and had the lowest virus titer. The analysis of virus showed the tomato plants infected by four begomovirus species previously shown to be associated with TYLCD in the area where the field trials were conducted. The only betasatellite so far shown to be associated with TYLCD in Oman, Tomato leaf curl betasatellite, was detected particularly in lines harbouring *Ty*-2, suggesting that the betasatellite may compromise *Ty*-2 resistance. Nevertheless, the results indicate that the Ty genes are useful in Oman and should be incorporated into local varieties. An update will be given about the status of the tomato disease complex and the potential new viral species and/or strains which are present in this part of the world.

O.18: Biosynthesis, characterization and antifungal activity of silver nano particles from *Lactuca virosa*

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The current research endeavors are mainly centered on metal nanoparticles due to their scarce properties such as electronic, optical, and magnetic; which often differentiate it from their bulk counterparts. Enormous progress have been achieved, to date, in metal nanoparticles synthesis; wherein, nanoparticles of palladium (Pd), silver (Ag), platinum (Pt), rhodium (Rh), nickel (Ni), and gold (Au) have been prepared with different morphologies. Among these, AgNPs could especially be promising due to their features such as excellent electrical performance, chemical inertness, thermal stability, antimicrobial activities, non-toxic and environmentally safe. As a consequence, the synthesis protocol for AgNPs nanoparticles that rigorously control the nano-size and morphological features of colloidal AgNPs are significant. Among diverse synthetic techniques solution-based protocol succeed towards preparation of monodisperse colloidal nanoparticles with controllable shapes and sizes. Various synthetic parameters have been found such as metal precursor, reducing agent, capping agent, reaction time, reaction temperature and pressure. In this regards, since last four decades researchers have been reported many techniques for synthesis of AgNPs, wherein all the above mentioned reaction parameters were screened. Although the current strategies suffers with some drawbacks such as use of toxic chemicals, high temperature, high pressure and production of hazardous by-products and waste etc. Eventually, it is necessary to search an alternative technique that overcomes above mentioned limitations in the synthesis of silver nanoparticles. In this concern, we describe a novel and green protocol that provide important new insights into the synthesis of colloidal AgNPs using plant extract. This suggested technique gives bypass to hazardousand expensive chemicals and offer size controlled AgNPs at mild reaction conditions, which is inexpensive, easy, simple, rapid, quick, simple scale up, easy to control and less energy extensive process. In typical synthesis protocol plant extract of *Lactuca virosa* leaves possessing rich concentration of biomolecules such as vitamins, polysaccharides, proteins, amino acids, enzymes, and organic acids were used as a reducing as well as capping agent. The synthesized silver nanoparticles were also characterized by UV-Vis spectrophotometry, FTIR spectroscopy, SEM and TEM. The reaction progress has been analyzed using FTIR that revealed the role of *L. virosa* leaves extract as a reducing agent in nanoparticles synthesis. The size of prepared AgNPs is in the range of 40- 50 nm, which determined by scanning electron microscope (SEM) and transmission electron microscope (TEM). The AgNPs synthesized by *L. virosa* leaves extract is a green solution with potent antifungal activities against plant pathogenic fungi *Fusarium oxysporum, Alternaria alternata* and *Macrophomina phaseolina.*

O.19: *In vitro* antifungal activity of plant latex extracts against resistant isolates of pathogens associated with ivy gourd

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The fruit rot of ivy gourd, *Coccinia indica* (Wight and Arn.) of the family Cucurbitaceae is caused by four different fungal pathogens i.e. *Bipolaris tetramera*, *Alternaria pluriseptata*, *Macrohomina phaseolina* and *Geotrichum candidus*. The *in vitro* antifungal effectiveness of plant latex extracts was evaluated for their botanical toxicants on four pathogenic fungi associated with ivy gourd. The antifungal effect of aqueous extracts of latex namely *Jatropa curcus, Calotropis gigentea, Ficus bengalensis* and *Ficus glomerata* were evaluated. The inhibitory effect was tested by food poisoning technique and determined minimum inhibitory concentration (MIC). Due to the presence of bioactive molecules, the latex extracts showed significant inhibition in different concentrations. *Jatropa curcus* showed 100% reduction of radial growth of *B. tetramera* and *A. pluriseptata* at 75% conc. To some extent, *F. bengalensis* also showed significant reduction of radial growth of *M. phaseolina* and *G. candidus* at 100% concentration.

O.20: Evaluation of *Trichoderma* spp. for biological control of charcoal rot of maize

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Trichoderma spp. are fungi that occur worldwide. Recent studies show that they are not only parasites of fungal plant pathogens but also can produce antibiotics. In addition, certain strains can induce systemic and localized resistance to several plant pathogens. Moreover, some strains may enhance plant growth and development. The potential of *Trichoderma* species used as biological agents of plant diseases have been known since the 1930s.There was variation in MICs of carbendazim among the sixteen isolates of *Macrophomina phaseolina* Tassi (Goid) causing charcoal rot of *Zea mays* L. Var. African tall *in vitro* tested by food poisoning technique. Among the sixteen isolates, isolate Mp3 was sensitive tolerating 1 ppm carbendazim while Mp9 was resistant and its MIC was 450 ppm. So, to manage such carbendazim resistance in *M. phaseolina* six *Trichoderma* spp. were screened against carbendazim sensitive and resistant isolates of *M. phaseolina* causing charcoal rot of maize by dual culture technique for their biocontrol potential. Among the six species of *Trichoderma, T*. *pseudokoningii* showed maximum antigonastic potential (79.63%) against resistant isolate of *M. phaseolina*. In remaining species of *Trichoderma*, *T. koningiopsis* showed 78.40% inhibition, *T. virens* showed 76.33%, *T. atroviride* showed 73.71%, *T. viride* provided 69.63%, and *T. harzianum* gave 67.04% inhibition of *the* charcoal rot fungus. Similarly, *T. koningiopsis* gave maximum inhibition of carbendazim sensitive isolate of *M. phaseolina* (82.96%) followed by *T. pseudokoningii* (80.74%), *T. virens* (79.63%), *T. atroviride* (77.41%), *T. viride* (75.93%) and *T. harzianum* (69.63%).

I.12: Impact of seed treatments with biocontrol agents on major yield reducing soil borne pathogens of soybean

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Top leading producers of soybean are United States (31% of the world's total), Brazil (31%), Argentina (19%), China (5%), India (4%), Paraguay (3%) and Canada (2%). Out of >200 pathogens affecting soybean Worldwide, some of the major soil borne pathogens (species of *Fusarium*, *Rhizoctonia*, *Pythium*, *Macrophomina* and *Sclerotinia*) affecting yields and the impact of seed treatments with biocontrol agents (species of *Trichoderma*, *Paraphaeosphaeria* formerly *Coniothyrium* and *Talaromyces*) on soybean yields discussed. Two steps were adopted to assess the impact of biocontrol agents (BCA). Initially, the BCA were evaluated *in vitro*, in dual culture plug method to assess their outcome on growth reduction, antagonism and mycoparasitism of target pathogens. Subsequently, the BCA were evaluated in field tests at multiple research farms of Iowa State University. Test results showed, reduction in disease(s), and advantages in yields and economic benefits over untreated controls. However, based on the test results, it was observed some challenges of test consistency and opened additional and or alternate avenues of soil and or foliar applications for management of some of the major soil borne pathogens and diseases of soybean.

O.17: Plant health and UN sustainable development goals

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The success of millennium development goals led the United Nations to adopt a new set of 17 sustainable development goals (SDGs) with 169 targets and 304 indicators on September 25th, 2015. The global goals which together are called Agenda 2030 officially came into force on 1 January 2016. The goals that universally apply to all nations, will mobilize efforts to end all form poverty, hunger, fight inequalities and tackle the alarming climate change and bring overall peace and prosperity as well as equitable and sustainable development of people on planet over next 15 years. Although the SDGs are not legally binding, countries were expected to take ownership and establish national frameworks for the achievement of these goals. As per the SDGs report 2018, progress has been recorded on several fronts, yet a large number of areas where comprehensive efforts are required to achieve the goals. The rate of extreme poverty has fallen rapidly, but as per latest global estimate 11 per cent of the world population, or 783 million people, lived below the extreme poverty threshold in 2013. World hunger is also on the rise again: 815 million people were undernourished in 2016 which are up from 777 million in 2015. Aid to agriculture in developing countries totalled $12.5 billion in 2016, falling to 6 per cent of all donors. Conflict, drought, disease, mineral deficiency and climate change are the key factors that adversely affect the soil and plant health, and consequently increase world hunger and food insecurity. Plant health is central to all the goals so far sustainable peace and development is concerned. If invested diligently in improving plant health, the agriculture, and mobilising scientific, technological and social movements, the challenges of extreme poverty and hunger can considerably be reduced by world society. In the present study an attempt has been made to investigate, how investing in improving soil and plant health can address the challenges of not only hunger, malnutrition and extreme poverty but also disease, illiteracy, clean water, energy, sustainable production and consumption, and climate change.

Technical Session IX

Panel Discussion: Policy and Capacity Development on Soil and Plant Health

I.11: Policy issues related to microbes, fungi and plant pathogens with reference to soil and plant health

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Sustainable agriculture is a worldwide keyword for the agriculture in the 21st century in which microorganisms of soil play a decisive role. Microbes including fungi posses wide potentialities as biocontrol and biostimulating agents. These abilities not only control diseases but also increase nutrients availability, accelerate decomposition of organic material which results in an anticipated increase of crop production besides maintaining sound environment. Microbial diversity, microbial load and presence of indicator microorganisms are useful indices to study soil health. Rhizosphere microbiota alleviate the biotic and abiotic stresses by different mechanisms. The policy issues need to be formulated, discussed, and implemented in the aspects *viz*., (1) Database for pests, diseases, and also for damaging pathogens has to be established, (2) Measurement of severity of disease symptoms, prediction of obtainable yields, inoculum quality, virulence, innovation of disease forecasting methodologies and creation of models, (3) Predicting the origin of next generation plant pathogens, (4) Strengthening of IDM along with varieties performing well in all geographic regions of globe along with their acclimatization to varied climatic conditions, (5) Expectation on the role of expected climate change on microbes, plant pathogen and crop protection, (6) Expectations on the role of transgenics in crop protection and global food security besides the application of nano-technology in crop protection, (7) Strengthening of studies on biodiversity, conservation and taxonomy of microbes, fungi and plant pathogens besides applying morpho-taxonomy, omics and molecular tools, (8) Control of new and emerging microbial/fungal pathogens and also insects, (9) Development of consortia may enable more resilient plant phenotypes than single strains, (10) Microbial and fungal communities, their organization and role in the ecosystem, (11) Microbes and fungi as fungal endophytes and their metabolism, (12) Intimate role of soil microbes in plant speciation, (13) Effective quarantine regulations are to be developed to prevent entry of alien/foreign pathogen, (14) GIS tagging of field gene banks and identifying traits in the germplasm so as to develop proper breeding programmes, (15) Establishment of quality standards for biocontrol and biostimulants of bacterial/fungal origin, (16) Biopesticide trade regulatory mechanism and problems in licensing (CIB & RC). (do we need a separate regulatory authority), (17) Registration is not required for biocontrol and biostimulate agents, then why farmers hesitate to use, (18) Development of training resources, (19) There is a necessity of bringing out an international agricultural biosecurity system for sustainable agriculture and (20) Implications of gene editing to improve disease or pest resistance.

I.08: Current scenario of biopesticides in India: Regulatory requirements for commercialization

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Biopesticides are naturally occurring biologically safe microorganisms used for the management of pests and diseases. The global market demand for microbial based bioinoculants is increasing annually. The estimated market for biopesticides has grown at a rate of 14% and is predicted to generate US$ 1.88 billion worldwide by 2020 and US$ 1.95 billion by 2022. Currently, it is estimated that nearly 80% of the global market revenues are recorded in Europe and Latin America. However, the acceptance and diffusion of biopesticides in Indian agricultural market is quite evident with the Indian contribution to the global biopesticide market being 2.89% during 2005, and a meager improvement to 5% by 2016. Biological control agents (BCAs) play major role in biological control of plant diseases, owing to their capabilities of ameliorating the crop-yields by multiple roles such as biopesticide and plant growth promotion. However, fast paced current research in this field should be carefully updated for the full-proof commercialization of the BCAs. In order to enhance marketability of these fungi and bacteria as BCAs, feasible commercial production processes are of utmost importance. Biopesticide registration needs data on technical and formulation related information such as biological characteristics, pathogenic contaminants, other microbial contaminants, bioefficacy, toxicity, container compatibility and self life etc. To achieve this, certain norms specified by Central Insecticides Board are to be followed. Till date, about 970 microbial based biopesticides products are registered with CIBRC (http://cibrc.nic.in/bpr.doc) under section 9(3B) and 9(3) of the Insecticides Act, 1968 Government of India. CIBRC has registered 568 fungal based products under section 9(3B) provisional, in which 325 different strains of *Trichoderma* has been included. Further under section 9(3), 45 fungal based products are registered. Current status of biopesticides in India with emphasis on parameters set up by CIBRC for registration and commercialization will be discussed.

Technical Session IVB

Poster Presentations (Sessions for Highlights of Posters)

P.01: Effect of sodium chloride salinity and distillery effluent on mineral nutrition in Dirt weed

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Sodium was accumulated in the *Chenopodium album* L. (Dirt weed) due to increasing NaCl salinity. Sodium content in *C. album* leaves was increased upto 10 EC and potassium content decreased upto 8 EC NaCl concentrations. There was also adverse effect of salinity on calcium uptake and distribution in test plant, however, Mg^{++} level showed its increase with increasing salinity. On the other hand iron uptake was reduced due to salinity. Similarly sodium concentration in *C. album* leaves was affected by increasing concentration of distillery effluent. In the same way potassium contents of the leaves of the test plant were declined with increasing concentration of distillery effluent. Further, uptake of calcium in the leaves of *C. album* was affected by distillery effluent. Calcium was accumulated at lower concentration, however, declined at higher concentration. Mg^{++} contents in *C. album* leaves were declined with increasing concentration of distillery effluent. Iron was accumulated in *C. album* leaves except in 40% concentration of distillery effluent.

P.02: Ecofriendly management of linseed blight caused by carbendazim resistant isolates of *Alternaria lini* Dey

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Minimum inhibitory concentrations (MICs) of carbendazim was varied among fifteen isolates of *Alternaria lini* causing leaf blight of *Linum usitatissimum L.* as determined by food poisoning technique. Among these fifteen isolates, isolate AL-9 was sensitive tolerating 3% carbendazim while AL-5 was resistant and its MIC was 22%. So, to manage such carbendazim resistance in *A. lini*, three *Trichoderma* spp. were screened against carbendazim sensitive and resistant isolates of *Alternaria lini* by dual culture technique for their biocontrol potential. Among the three species of *Trichoderma, T. harzianum* showed maximum antigonastic potential (82.22%) against resistant isolate of *A. lini* having resistant factor 7. In remaining species, *T. viride* showed 74.44% inhibition and *T. asperellum* gave 69.44% inhibition of *A. lini*. Similarly, *T. harzianum* gave maximum inhibition of carbendazim sensitive isolate of *A. lini* (77.22%) followed by *T. viride* (68.33%) and *T. asperellum* (64.44%).

P.03: Management of linseed blight by green silver nanoparticles synthesized from *Simarouba glauca* for development of organic culture

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In the present work an attempt was made to synthesize silver nanoparticles by using medicinal plant *Simarouba glauca* DC. and assessment of antifungal potential against *Alternaria lini*. Synthesized nanoparticles are spherical in shape. The size was ranging between 30-50nm for nanoparticles synthesized using leaves sample, 50-60nm for nanoparticles synthesized by bark sample. Silver nanoparticles synthesized from leaves and bark extract of *S. glauca* have potential to inhibit the growth of carbendazim resistant strain *Alternaria lini*, causing linseed blight. Silver nanoparticles synthesized from leaves showed higer inhibitory activity than nanoparticles synthesized from bark sample. Thus the silver nanoparticles synthesized from *S. glauca* was useful in managing the pathogen and maintaining the crop yield. This will reduces the residues of fungicides and also useful in the development of chemical free organic farming.

P.04: Management of late blight of tomato disease in Sirmour areas of Himachal Pradesh

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Tomato (*Solanum Lycopersicon* L) is one of the most widely grown vegetable crop in the world. In Himachal Pradesh, it is grown on about 9,930 hectares with an annual production of more than 4,13,709 metric tonnes and major varieties grown in State are Himsona, Solan lalima and Arakshita. Fungal diseases are of most economic importance and are responsible for huge losses to the growers. Among them, the Oomycete *Phytophthora* represents one of the most serious threats to production. Extensive disease survey was conducted in different tomato growing areas of Himachal Pradesh for recording the incidence of disease and collected disease samples from each location. The pathogen was isolated separately on artificial growing media and the isolated pathogen associated with the disease was identified on the basis of morphological characters. Fifteen different varieties of tomato *viz*., Hisar lal, Punjab Verkha Vihar 2R, Late blight IR, Himsona, Solan lalima, Late blight resistant, Punjab Verkha Vihar, LRR-15, PNR-7,Arka Samrat, Arka Rakohok, BT-1-1, Palam Pride, EC27995 and EC267127 were evaluated for their relative resistance to late blight during May to July, 2017. None of the variety showed resistant reaction though varieties *viz*., Punjab Verkha Vihar 2R exhibited highly susceptible reaction. Disease management with chemicals, biocontrol agents and bioformulations was carried out individually. The combination Metalaxayl + Mancozeb among various fungicides was effective and among botanicals cow urine was most effective in inhibition of the growth of the pathogen.

P.05: Application of a new chemical molecule against diseases of corn

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Field experiment was conducted to document the presence of different diseases of corn grown in the Teaching farm at College of Agriculture, Burdwan, BCKV. The region representing the old alluvial zone of West Bengal. A most popularly grown corn variety 'PAN 6015' was raised during *rabi* season of the two consecutive years 2016 and 2017. Along with scoring of different diseases, few new chemicals *viz*. Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS at three doses i.e 2.0 g a.i, 2.5 g a.i and 3.0 g a.i per kg seed were evaluated for their bioefficacy and phytotoxicity and compared with Pyraclostrobin 20% WG 0.2 g a.i per kg of seed, Thiophanate Methyl 70% WP 1.4 g a.i. and Fipronil 5% SC 0.5 g a.i per kg seed individually. Carbendazim 50% WP 1.5 g a.i and Thiamethoxam 30% FS 2.4 g a.i were also included for comparison of the bioefficacy. For phytotoxicity, only two doses of Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS @ 2.5 g a.i and 5.0 g a.i kg of seed^{-1} were tested and assessed. The experiment was conducted in the field under natural epiphytotic condition in RBD. For bioefficacy, 9 treatments with 3 replications and for phytotoxicity 3 treatments with 7 replications were maintained. The prevalence of diseases were culvularia leaf spot, northern leaf blight, stalk rot of maize *(Erwinia chrysanthemi)*, charcoal rot (*Macrophamina phaseolina*), turcicum leaf blight (*Bipolaris turcica). Highest disease incidence (45.5%) and severity (PDI: 75.09) were observed in case of curvularia leaf spot followed by turcicum leaf blight (incidence 39.3% and PDI: 61.23) and northern leaf blight (incidence 35.3% and PDI: 56.23). Rest of the diseases were observed late in the season with very poor incidence where incidence of stalk rot of maize and* Charcoal rot *had 5.06% and* 7.56% incidence, respectively. For evaluation of bio-efficacy and phytotoxicity of new molecules only the dominant disease i.e curvularia leaf spot was taken into consideration. Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS @ 3 g a.i kg seed^{-1} was highly effective and resulted in reduction of disease severity 57.28% along with the higher yield. It was followed by Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS @ 2.5 g a.i kg seed^{-1} with 54.29% control of the disease compared to the untreated control.The phytotoxicity of two different doses of Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS @ 2.5 g a.i and 3 g a.i was found equally effective to check the curvularia disease of corn and increased yield without developing any phytotoxicity symptoms on the crop in either of the cases. The study exhibited the new molecule Pyraclostrobin 25 g/l + Fipronil 250 g/l + Thiophanate Methyl 225 g/l FS having a higher efficacy as seed treatment with a little chance of environmental hazard and hence the novel chemical molecule can be incorporated in integrated disease management programme.

P.06: Efficacy evaluation of *Bacillus subtilis* and *Trichoderma harzianum* in suppression of *Fusarium* wilt in *Solanum lycopersicum*

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Bacillus and *Trichoderma* are known for their antagonistic activities against various phytopathogens. The present work was conducted to investigate the antagonistic efficacy of *B. subtilis* and *T. harzianum* against *Fusarium* wilt in *Solanum lycopersicum*, individually as well as in combination, and compare its efficacy with the current practise of amendment with chemical control. *Fusarium oxysporum* f. sp. *lycopersici* is the fungal soil borne phytopathogen causing this disease. In *in vitro* dual culture assay, *B. subtilis* (MTCC 2274) and *T. harzianum* (MTCC 3928) exhibited mycelial growth inhibition of 85.7% and 73.3% against *F. oxysproum*, respectively. Both biocontrol agents were capable of producing hydrolytic enzymes *viz.*, chitinase (33.69 and 154.23 U ml^{-1} min^{-1}), protease (929 and 846U ml^{-1} min^{-1}) and β-1,3-glucanase (12.69 and 21.47 U ml^{-1} min^{-1}), respectively. In *in planta* assay, it was found that consortium of *B. subtilis* and *T. harzianum* exhibited highest disease reduction (56%) followed by *B. subtilis* (44%) and *T. harzianum* (40%) whereas with chemical control (carbendazim) it was 48.7% as compared to untreated control. Additionally, the inoculation with consortium of *B. subtilis* and *T. harzianum* significantly enhanced the plant growth parameters. Increment in fresh weight (4.49 fold), shoot length (3.58 fold), root length (2.57 fold), chlorophyll-a (76%), chlorophyll-b (1.1 fold), total chlorophyll (86%), total phenolic content (88%) and total soluble protein (1.23 fold) was observed. This suggests that *B. subtilis* and *T. harzianum* consortium could serve better in mitigation of wilt disease and plant growth enhancement of *S. lycopersicum* as compared to single inoculant.

P.07: Bacteriophages of *Pseudomonas savastanoi* pv. *savastanoi*, its isolation and characterization

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Bacteriophages or the phages are the viruses that parasitize bacteria. Due to several attributes like being safe to the environmentally, minimum disruption to micro biota, ability to break the formation of biofilms, solving the problem of antibiotic resistant bacteria etc., the bacteriophages are considered as potential biocontrol agents. The present study was undertaken to isolate and characterize the bacteriophages infecting *Pseudomonas savastanoi* pv. *savastanoi*, the causal agent of one of the most important bacterial diseases of olive known as the olive knot disease. The bacterium was cultured in King's B medium where it produced florescence under UV. For confirmation of the host bacterium, PCR analysis of the bacterial DNA was carried out using specific primers (IAALF: IAALR) which gave an amplicon size of 454 bp. In this study, 11 lytic bacteriophages infecting *P. savastanoi* pv. *savastanoi* were isolated from an olive knot infected field in Agria, Volos, Greece. For morphological characterization, transmission electron microscopy (TEM) was carried out for 505 phage particles that were stained with 1 per cent Ammonium Molybdate, 2 per cent UA (Uranyl Acetate) and 2 per cent PTA (Phospho Tungstic Acid). Observation of phages in TEM revealed that the particles of all the 11 purified samples had an icosahedral head along with a tail and a base plate hence was classified under the order *Caudovirales*. Study of the tail morphology suggested that the samples had a long, flexible and non-contractile tail with its breadth ranging from 9.43±1.19 nm to 12.75±2.83 nm suggesting that the sample phages had affinity to the phage family *Siphoviridae* under the Order *Caudovirales*. Molecular characterization of the isolated phages was carried out by Next generation sequencing (NGS). The bioinformatics analysis of the sequences suggested that the genomes of the sample phages were more homologous to the genomes of 'Proteus phage vB_PmiS-TH', 'Caulobacter phage Ccr29' and 'Staphylococcus phage Andhra' than the already existing Pseudomonas phages. It was also observed that the sample phage genomes had a similarity of only up to 24 per cent with already identified phage genomes indicating the presence of some novel bacteriophages that are yet to be characterized.

P.08: Effects of some rhizosphere biocontrol agents on rice root-knot nematode, *Meloidogyne graminicola*

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Investigations were carried out to evaluate the effects of indigenous rhizospheric isolates of fungal and bacterial biocontrol agents (BCAs) for the management of rice root-knot nematode, *Meloidogyne garminicola* on rice cv. PS-5. Nematicidal activity of culture filtrates (CF) of BCAs was noticed on egg hatching and juvenile mortality *in vitro* and considerable variability in virulence among the isolates were recorded. Out of twelve, six most efficient isolates were selected to ascertain their effectiveness under pot condition (Pi = 1000 J_2 /kg soil). The BCAs (2-3 × 10^6 CFU/ml) were applied as soil application at one day before planting. Plants grown in the nematode inoculated soil without any treatment developed characteristic terminal galls on roots and suffered 24-30% decrease in the plant growth and yield. However, applications of BCAs suppressed the negative effect of rice root-knot nematode and subsequently increased the plant growth and yield of rice. Soil application of *P. fluorescens* AMUPF-1 provided a better control of the root-knot disease compared to rest of the BCAs and increased the plant growth by 9-19% and grain yield by 31%. The frequency of BCA colonization on eggs, juveniles and adult females of *M. graminicola* was highest with *Paecilomyces lilacinus* AMUPL-1 (20-34%), followed by *Trichoderma harzianum* AMUTH-1 (15-22%) and lowest with *Bacillus subtilis* AMUBS-1 (4-12%). However, the greatest buildup in the rhizospheric population of the BCA was recorded with *P. fluorescens* AMUPF-1, followed by *T. harzianum* AMUTH-1 and *P. lilacinus* AMUPL-1 in comparison to the initial population. The study has demonstrated variable effectiveness of BCAs with greater antagonism by *P. fluorescens* AMUPF-1 than *P. lilacinus* AMUPL-1 against *M. gramincola*. *T. harzianum* was also found quite effective in suppressing the *M. graminicola.* The BCA acted as an endophyte and colonized the female, eggs and juveniles of the nematode. Field trials under naturally infested plots also validated the efficacy of *P. fluorescens* and *T. harzianum,* and satisfactorily controlled *M. graminicola* with significantly improved tillering and rice yield by 60-74%.

P.09: Serodiagnostics through polyclonal antisera production and molecular characterization of *Potato virus Y* isolate from Jorhat district of Assam

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Potato production is affected by various viral diseases which reduce yield quality and quantity. Amongst all the viruses, *Potato virus Y* (PVY) is recognized as one of the most economically important virus of potato causing severe mosaic disease. For the study, PVY isolate was maintained on its host potato (*Solanum tuberosum.* L) and purification was done from the leaves following standard procedure to obtain purified viral protein. Purified viral protein (antigen) was used for raising rabbit polyclonal antibodies through immunizations where first injection was given with Freund's complete adjuvant and subsequent two injections were given with Freund's incomplete adjuvant at alternate weeks followed by four booster doses after a rest period of 6 weeks. After it, four batches of good quality antisera (AS4b, AS5b, AS6b and AS7b) were collected one week post boosters and the IgG fractions were separated through ammonium sulphate precipitation method. Double Antibody Sandwich- Enzyme linked Immunosorbent Assay (DAS- ELISA) of all the IgG fractions from the booster doses with universal anti- rabbit enzyme conjugate as secondary antibody showed high specificity with the known PVY infected and healthy potato samples and the assay was compared with the commercial DAS- ELISA kit (Bio Reba, AG, Switzerland). The assay was quantitative, replicated five times and analysed statistically. IgG titres for the four batches were measured using a series of IgG dilutions from 10^{-3} to 10^{-6} with conjugate dilution maintained at 10^{-3}. Significant differences were observed in the titres of these four batches of IgG at 10^{-3} dilution. At that dilution, AS6b showed significantly highest absorbance values with PVY infected plant extracts followed by, AS5b, AS7b and AS4b, respectively. For further confirmation of presence of the virus in the tested samples, total RNA was isolated from infected potato sample from field and standardization for reverse-transcriptase polymerase chain reaction (RT-PCR) conditions were done using a primer set based on the coat protein gene for detection which gave the desired 328 base pair product. Partial sequencing of the RT-PCR amplicons revealed that the virus is closely related to *Potato virus Y* and sequence analysis showed high sequence homology with PVY isolates from different countries worldwide.

P.10: Characterization and *in vitro* management of *Choanephora cucurbitarum* on cabbage and cauliflower in Kerala, India

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Characterization of the fungus causing leaf blight and head rot in cabbage and curd rot in cauliflower, *Choanephora cucurbitarum* was done using morphological and cultural characters and was confirmed by molecular methods. The purposive sampling survey conducted at four districts of Kerala showed a maximum disease severity of leaf blight and head rot in cabbage (40.9%), curd rot in cauliflower (12.4%) from Chullikkara area of Kasaragod district, Kerala state in India. The symptoms started on lower leaves of cabbage as water soaked, depressed papery white lesions with grey centre, having pale green border and irregular shape. Later spots coalesced to cause blighting of leaves with inward curling and black sporulation of the fungus on all the infected parts. Infection on head produced similar symptoms with soft rot of the head causing severe yield loss. In cauliflower infection on leaves caused water soaked lesions near the margin of leaves causing folding of leaves. On curd of cauliflower, pathogen produced watery soft rot forming white puffy growth with offensive smell. *Choanephora cucurbitarum* from cabbage and cauliflower produced creamy white colony with cottony aerial mycelium and sporulation was observed on the periphery of the Petri plate. Microscopic studies showed that sporangiola were formed at the apex of 14.30-16.41 µm wide sporangiophores. Monosporous sporangiola were ovoid, brown to dark brown with striations on the surface. They measured 12.22-14.85 µm x 6.66-9.61 µm in size. Sporangia were globose to sub-globose shape with 32.80-74.91µm diameter. Sporangiospores were found as brown in colour, elliptic to ovoid in shape and 12.68-18.38 µm x 6.48-7.99 µm size. The result of *in vitro* evaluation of the fungicides against *Choanephora cucurbitarum* revealed that tebuconzole 5EC (Folicure) (0.05%, 0.1%, 0.15%) carbendazim (0.05%, 0.1%, 0.15%), copper oxychloride 50 WP (Blitox) (0.1%, 0.2%, 0.3%), trifloxystrobin 25% + tebuconazole 50% (Nativo) (0.02%, 0.03%, 0.04%) and propineb 70 WP (Antracol) (0.2%, 0.3%, 0.4%) showed hundred per cent inhibition of the pathogen. Bordeaux mixture also showed 100% inhibition at 1 and 1.5 per cent concentrations. *Trichoderma viride* was most effective against *C. cucurbitarum* with 74 per cent inhibition of mycelial growth. *Pseudomonas fluorescens* inhibited 65 per cent mycelial growth of the pathogen whereas *Bacillus subtilis* restricted the mycelial growth upto 47.5 per cent.

P.11: Biological control of *Alternaria brassicae*, the causal agent of *Brassica* leaf spot disease, using rhizospheric bacteria

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Indian mustard (*Brassica juncea* Coss. & Czern) is an important oilseed crop in India. Among various diseases infecting mustard crop, Alternaria leaf spot, also known as Alternaria blight is incited by fungus *Alternaria brassicae*, which causes a yield loss of up to 70%. The disease is controlled by application of different fungicides prior to winter rains but it is costly and also cause pollution in the environment. Present investigation was designed to explore the potential of rhizospheric bacteria to use as bio control agents for suppression of the disease. Total of thirty-five bacterial isolates were isolated from the rhizosphere of mustard, tomato and brinjal and they were screened for their antagonistic activity against *A. brassicae in vitro* conditions. Out of which sixteen isolates showed antagonistic ability to form an inhibition zone ranging diameter from 3 to 4.5 cm against *A. brassicae*. Three of them denominated as BM1, BM2 and BM3 were most effective with inhibition rates of 92.95, 87.8% and 90.78%, respectively. Antagonistic rhizospheric bacterial isolates were examined for their plant growth promoting activities such as IAA production, HCN production and ammonia production *in vitro* conditions. Maximum IAA production among (43.75%) was shown by isolate BM3 and BM12 with color change from white to pink; high ammonia production among (58.25%) was observed in isolates BM21, BM3 and BM9 with color change to yellow adding Nessler's reagent. Six isolates *i.e.* BM25, BM2, BM5, BM19, BM3 and BM7 showed HCN production (68.75%) with blackening of test strip. Biochemical characteristics like starch hydrolysis, oxidase, lipase, gelatin and catalase were also performed by descriptive methods. The results of the study provided possibilities for bacterial isolates that could be used as effective bio control agents against Alternaria blight disease. However, further analysis and experiments are required to evaluate the efficacy of the bacteria under field conditions.

P.12: Impact of climate variability vis-á-vis yield loss on the occurrence of sesamum phyllody disease in Jorhat district of Assam, India

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Sesamum phyllody is an alarming disease of sesamum caused by sesamum phyllody phytoplasma. The leafhopper vector *Hishimonus phycitis* (Dist.) plays an important role in the spread of this disease. Studies on effects of various meteorological parameters on the sesamum phyllody disease development and assessment of yield loss was carried out on sesamum crop by growing at different dates of sowing during summer and *kharif* season, 2017 in Jorhat district of Assam, India. The disease incidence increased with delay in sowing during summer and *kharif* season. The highest incidence of 17.60 per cent in summer and 22.16 per cent in *kharif* season was observed in the crops sown on 15th April, 2017 and 1st August, 2017, respectively. Crops affected at early growth stages produced symptoms like stunting, reduction in leaf size and yellowing of leaves *etc.,* while floral virescence, phyllody, floral proliferation and cracking of pods were observed in the crops affected after flowering. PCR assays with universal primers P1/P6 confirmed the presence of phytoplasma in the plant samples as well as in the vector *H. phycitis*. Correlation analysis of sesamum phyllody disease with the meteorological parameters showed that temperature and relative humidity were positively correlated, while diurnal variation and sunshine hours were negatively correlated during summer season. During the *kharif* season, maximum temperature and diurnal variation were positively correlated while wind speed, total rainfall and number of rainy days were negatively correlated. The yield attributing characters *viz.*, number of pods per plant, number of seeds per pod and 1000 seed weight were taken into account for yield loss assessment. The highest reduction in number of pods per plant and number of seeds per pod was observed as 79.39 per cent and 56.95 per cent, respectively during the summer season, while in the *kharif* season, reduction for the above mentioned parameters were 80.33 per cent and 61.25 per cent, respectively. No significant difference was observed for 1000 seed weight among the different sowing dates for both the seasons. The yield of sesamum was also affected by the disease since with the increase in disease incidence the yield started to decrease.

P.13: First record of *Myrothecium roridum* causing leaf spot disease in gerbera

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Gerbera, a popular ornamental crop is cultivated throughout the world for cut flower as well as for ornamental potted plants. It has a unique position in cut flower industry with very good export potential because of its graceful appearance, hardiness, ability to withstand transportation and long shelf life. Since gerbera flourishes well under the warm humid tropical climate of Kerala, the crop is prone to infection by different fungal pathogens which thrive well under such conditions. The present study is focused on the isolation, cultural and morphological characterization of a peculiar leaf blight pathogen which is noticed for the first time affecting gerbera. A sampling survey in gerbera growing tracts of Thrissur district revealed the occurrence of an unusual leaf blight where the crop was grown under protected conditions in hydroponic system. Three month old plants were found affected with the disease which was observed only during November-December months with a per cent disease incidence and severity of 53.1 and 9.1, respectively. The disease became severe due to the prevalence of favourable temperature of 23.8-31.9°C, relative humidity of 65-75 per cent and rainfall of 88.3-151.2 mm. However, the disease was less prominent especially during summer and monsoon season. Hence, it may be inferred that the pathogen prefers low temperature and high moisture condition for perpetuation and spread of the disease. The pathogen was isolated from diseased samples and its pathogenicity was proved by Mycelial Bit Inoculation Method (MBIM) and Mycelial Droplet Inoculation Technique (MDIT). Black water soaked lesions were observed on upper surface of leaf lamina which later enlarged to form large blightened areas that appeared circular or sub circular with grey or black coloured concentric zonations along with a black border in the margin of the leaves. The pathogen produced white, floccose, concentric ringed colony with irregular shapes of dark green to black sporodochia. Conidiophores had 2-4 branches at each node while phialides were hyaline, cylindrical, in whorls of 3-5 and measured 13 to 16 × 2.0 µm. Conidia hyaline, one-celled, rod-shaped with rounded ends and measured 5 to 10.74 × 2.0 µm. The above characteristics confirmed the pathogen as *Myrothecium* sp. and later the species was identified was carried out from National Center for Fungal Taxonomy (NCFT), New Delhi as *Myrothecium roridum* (ID No. 7948.15). The cultural and morphological characters of the pathogen of this study were matching with the description of *Myrothecium roridum* causing leaf spot in begonia. This is the first report of *M. roridum* causing leaf blight in gerbera.

P.14: Bio-efficacy of new fungicide molecules against early blight and Septoria leaf spot diseases of tomato

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Early blight (*Alternaria solani*) and Septoria leaf spot (*Septoria lycopersici*) diseases are the most economically important and destructive foliar diseases of tomato and have become major constraints in tomato yield. As most of the commercially cultivated hybrids/varieties are susceptible to these diseases, farmers usually depend upon fungicides to manage these diseases. Many fungicides are available for these diseases. However, frequent and continuous use of the already available effective fungicides might lead to the development of fungicidal resistance against these diseases. Therefore, there is a need to test new fungicide molecules to achieve higher efficacy with little adverse effects. With this background, a field experiment was conducted during *kharif* season of 2016-17 to evaluate the new fungicide molecules *viz*., Fluxapyroxad (0.04%) and pyroclostrobin (0.1%) individually and also a combi product of the same fungicides (at 4 different dosages *viz*., 0.03, 0.04, 0.05 and 0.06%) along with commonly used fungicide like propineb (0.3%). The disease severity was expressed in terms of Per cent disease index (PDI). Among the various fungicides, the combi product Fluxapyroxad 250 g/l + Pyraclostrobin 250 g/l 500 SC @ 0.06 percent was most effective registering least PDI of 4.00 followed by the same fungicide at different doses of 0.05 and 0.04 per cent with PDI of 6.67 and 9.33 respectively. Maximum PDI was recorded in untreated control (30.67). Similarly, the same fungicides were evaluated against septoria leaf spot disease and the results indicated that the combi product of Fluxapyroxad + Pyraclostrobin @ 0.06 percent gave maximum disease control (5.33 PDI) followed by the same fungicide @ 0.05 per cent dosage (8.00 PDI). Maximum septoria leaf spot disease severity (30.67 PDI) was recorded in untreated control**.** The same product @ 0.04 per cent (9.33 PDI) and @ 0.03 per cent (10.67 PDI) was found effective against septoria leaf spot disease as compared to fungicides Pyraclostrobin @ 0.1 per cent (12.00 PDI), Fluxapyroxad @ 0.04 per cent (13.33) when tested alone and Propineb @ 0.3 per cent (14.67). The highest yield was recorded in Fluxapyroxad + Pyraclostrobin (0.06%) treated plot (33.83 t/ha) followed by the plots treated with the same fungicide at different doses of 0.05, 0.04 and 0.03 per cent with yield of 31.43, 27.50 and 26.03 t/ha respectively. The least yield was recorded in untreated control (22.97 t/ha).

P.15: Revealing the population structure of *Rhizoctonia solani* AG-1 IA isolates causing sheath blight of rice in different agro-climatic zones of Haryana, India

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Sheath blight of rice caused by *Rhizoctonia solani* Kuhn has emerged as one of the major disease causing substantial quantitative and qualitative losses. Keeping that in view, the relatedness of sixty six *Rhizoctonia solani* isolates collected from different sources and locations of Haryana, was determined by studying comparative cultural, morphological and pathogenic characters. There was no correlation between source of origin and geographical location with the morphological, pathogenic and genetic composition of the fungal isolates. The isolates of *R. solani* varied considerably with respect to cultural and morphological characters *viz*., mycelial growth rate, number of sclerotia formed, mycelial width, colour of mycelium and sclerotium. However, most of the isolates were similar based on their pathogenic behaviour on five rice cultivars reflecting that *R. solani,* being a necrotrophic fungus, has not evolved much due to non existence of selection pressure on it. Molecular characterisation of genetic diversity of *R. solani* isolates was studied by using rDNA ITS region sequencing, eleven inter simple sequence repeats (ISSR) and five universal rice primers (URPs). The size of amplified DNA bands ranged 0.2-3.5 kbp with ISSR primers and 0.2-3 kb with URPs. Phylogenetic analyses based on the rDNA ITS region sequencing indicated that analyzed seventeen *Rhizoctonia solani* isolates characterized into two groups which correlated with the morphological and pathogenic characters.

P.16: Association of leafhopper vectors and alternate hosts in transmitting sesamum phyllody phytoplasma and its molecular characterization in Assam, India

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Sesamum phyllody is a very serious and destructive disease of sesamum associated with phytoplasmas. It is an unculturable, wall-less bacterium (class Mollicutes) which lives inside the phloem of host plant and in the haemolymph of insect vectors. Sesamum phyllody disease associated symptoms such as floral virescence, phyllody, floral proliferation, splitting of capsules, witches broom were observed in the field of Assam state. The disease incidence recorded was 19.04%. Four leafhopper species *viz., Exitianus indicus* (Dist.), *Hishimonus phycitis* (Dist.), *Cofana unimaculata* (Dist.) and *Orosius albicinctus* (Dist.) were indentified in the field. Transmission studies were done by *Orosius albinctus* (Dist.), grafting, dodder, seed and sap. The confirmation of the disease was detected in diseased leaf samples through PCR and electron microscopy. Similarly, presences of phytoplasma were also detected in *E. indicus*, *H. phycitis* and *O. albicinctus* but not in *C. unimaculata* by PCR. Four alternate weed species were also identified in the field and indexed through PCR. The sesamum phyllody disease was successfully transmitted by graft transmission and dodder but neither by seed nor sap inoculation. There was no effect in germination of seeds collected from infected sesamum plants. Sequencing was done in two sesamum phyllody isolates and three insect species and four weed species. BLAST analysis showed 94 to 99% similarities with other phytoplasma isolates reported. Phylogenetic analysis was done in MEGA 6 software and it shows that *E. indicus* is closely related to North American grapevine yellows phytoplasma. *E. indicus* positive by PCR could be a new vector for sesamum phyllody phytoplasma transmission.

P.17: Eco-friendly management of Rice blast disease caused by *Pyricularia oryzea* in field condition at Uttarakhand, India

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Rice blast caused by *Pyricularia oryzea* is considered as one of the most important disease of rice (*Oryza sativa L.*) because of its wide distribution and destructive nature under favorable conditions resulting in serious loss of yield. Pesticides used for the management of plant diseases cause health hazards and environmental pollution. Keeping this in view, field studies were conducted during *kharif* season to determine the effect of *Cynodon dactylon* (Bermuda grass/doob grass) leaves extract, fresh rhizomes extract *of Curcuma longa* (Turmeric), fungal antagonist (*Trichoderma harzianum*) and bacterial antagonist (*Pseudomonas fluorescens*) against the rice blast pathogen in Udham Singh Nagar, Uttarakhand. The experiment was laid down on Dehraduni basmati rice (Type-3) in randomized block design (RBD) with three replications. Strains of *T. harzianum* and *P. fluorescens* were obtained from hill campus, Ranichauri Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar, India). Both biocontrol agents were used alone and in their consortium form, and applied through the seedling treatment and foliar spray @ 10 gm/l. Seedling treatment + two foliar sprays of *T. harzianum*, *P. fluorescens*, two foliar sprays of *C. longa* @ 0.5, 1.0 and 1.5% and *C. dactylon* @ 1.5% were given after 45 and 60 days. Severity of blast disease on foliage recorded after three days of final spray in 0-5 scale. Two foliar sprays of *C. longa* @ 1.5% recorded 22.85 percent disease incidence (PDI) at 45 days after transplanting (DAT) and 12.38 PDI in 60 DAT. This was followed by two foliar sprays of *C. longa* (1.0%) with 23.48 PDI at 45 DAT and 15.24 PDI at 60 DAT. *Pseudomonas fluorescens* recorded 25.71 PDI at 45 DAT and 16.19 PDI at 60 DAT over control conditions. Disease rating of *C. longa* (1.5% and 1.0%) foliar sprays showed remarkable results as compared to other treatments. The grain yield was maximum (25.6 q/ha) in the spray of *C. longa*, as against the yield of control plots (15.0 q/ha). Overall, grain yield in all the treatments was significantly higher than control.

P.18: Physiological characterisation and standardization of culture medium for *Ophiocordyceps neovolkiana* (Kobayasi) from Kerala, India

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The mysterious fungus *Cordyceps* sp. recommended by Chinese medicinal practitioners as a 'Panacea of all Ills' are mostly confined to high altitude ecosystems. *Cordyceps* sp., renamed as *Ophiocordyceps* sp. attacks coconut root grubs (*Leucopholis coneophora* Burm.) in coastal sandy areas of Kasargod district of Kerala state in India. The present study concentrated on molecular and physiological characterization and standardization of culture media for *Ophiocordyceps* sp. during 2016-2018. The molecular characterization by ITS sequencing of the culture showed homology with *Ophiocordyceps neovolkiana* (Kobayasi). This sequence was deposited in the Gen Bank of National Center for Biotechnology Information (NCBI) with an accession number MH 668282 and the culture of the fungus was deposited in National Fungal Culture Collection of India, a national facility by MACS Agharkar Research Institute, Pune, India with an accession number NFCCI 4331. To find out the optimum medium for the growth of fungus, five different media *viz.,* potato dextrose agar (PDA), yeast potato dextrose agar (YPDA), malt extract agar (MEA), oatmeal agar (OMA) and Czapek dox agar (CDA) were selected. Among these, YPDA was found best followed by potato dextrose agar (PDA). Evaluation of physiological characters of *O. neovolkiana* showed 30ºC as optimum temperature, 7.0as optimum pH, fructose as the best source of carbon, yeast extract as the best source of nitrogen, KH_2PO_4 and $ZnCl_2$ as the best source of macro and micro minerals, folic acid as the best source of vitamin in which the mycelial growth was maximum, when grown under 24h darkness in incubator. By combining all the optimum conditions a new medium was standardized and named as Yeast Extract Potato Fructose Agar (YEPFA) for the growth of *O. neovolkiana,* which was prepared by using 300 g of potato, 20 g of fructose, 5 g of yeast extract, 1 g of KH_2PO_4, 500 mg of $ZnCl_2$, 10 mg of folic acid and 20 g of agar in one litre of distilled water. The growth of the fungus in the YEPFA medium was significantly higher than YPDA and PDA, so that the time required for the mycelial growth could be considerably reduced from days 55.15 to 30.85 days. The mycelial weight was also significantly higher in YEPFA broth at 32.57 days of growth. Different cereal grains *viz.*, rice, wheat and sorghum were tried for artificial culturing of *O. neovolkiana* under *in vitro* conditions and sorghum grains was found to be the best substrate for mycelial growth followed by rice and wheat. The number of days needed for coverage of the mycelium in 50g of grains was 96.43 days for sorghum which was significantly less as compared with rice (115.15 days) and wheat (142.15 days).

P.19: Identification, Detection and Molecular characterization of Citrus Greening Disease in Assam using Real Time PCR

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Citrus Greening Disease (CGD), also known as Huanglongbing is a widespread and severe disease of citrus caused by an unculturable fastidious phloem limiting bacteria (*Candidatus Liberibacter asiaticus)*. It is transmitted by budding and also by Psyllid vectors (*Diaphorina citri* and *Trioza erytreae*) to many citrus species. On an average, the disease can cause 30 to 100 per cent yield loss around the globe. Khasi mandarin (*Citrus reticulata*) is an economically important citrus grown in Assam state of India. Field survey for CGD associated symptoms on Khasi mandarin leaves such as small and upright leaves, chlorotic mottling in citrus growing areas of Tinsukia, Jorhat and Golaghat districts of Assam was conducted and symptomatic leaf samples were collected from the surveyed areas. DNA was extracted from the collected leaf samples using Cetyl trimethylammonium bromide (CTAB) method, then followed by PCR analysis using CGD primer pair A2 (Forward 5' TATAAAGGTTGACCTTTCGAGTTT3') and J5 (Reverse 5' ACAAAAGCAGAAAATAGCCACGAACAA 3') for amplification. The PCR product was later resolved in gel electrophoresis. All the samples yielded a 700 base pair in gel electrophoresis and were further sequenced. Furthermore, quantitative analysis of citrus greening was also done by Real Time PCR using SYBR Green. The amplification curves for duplicated assays were overlapping and had a mean Ct value of 29.42 for the healthy sample while Ct values for the infected leaf samples from Tinsukia, Jorhat and Golaghat were 21.74, 22.5 and 22.9, respectively. The sequencing result showed 95-99 per cent similarities with other isolates of *Candidatus Liberibacter asiaticus*.

P.20: Application of seed priming techniques for offseason (*Boro*) healthy seed production and disease control of rice in Assam

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Assam is one of the major rice growing states in India and about 0.5 million ha of *Sali* rice growing area is chronically affected by flood and sometimes it affects more than 1 million ha. Ranjit (IET-12554) is the most popular rice variety in Assam. It has shown 66% increase in productivity in Assam. It is a semi-tall (105-110cm) variety with moderate tillering ability (10-12 tillers) and is recommended for shallow submergence (0-30cm water depth) areas in *Sali* season in Assam. It is photoperiod insensitive and takes 150-155 days to mature and yields 5.5 ton/ha. It is also resistant to bacterial leaf blight disease. Offseason seed production of paddy will help the farmers in meeting their requirement of quality seed during flood & other catastrophe. Seed priming is a technique involving the physiological aspects (seed hydration) of seeds and allowing the start of germination preparatory processes without permitting radical protrusion. In Priming, Seeds are soaked in different solutions with high osmotic potential, preventing the seeds from absorbing in enough water for radicle protrusion and suspends the seeds in the lag phase. Seed priming has been commonly used to reduce the time between seed sowing and seedling emergence. In this study priming was done to study the effect of different priming procedures on overall potential of rice seeds. Seeds of rice cultivar of Assam, *Ranjit* (IET-12554)*, Bishnuprasad* (control)*, Jyotiprasad* (control) each represented by a lot were used. The treatments consisted of: Control, Chemical priming with salicylic acid and melatonin, Osmopriming with PEG6000 solution, Hormonal priming with GA_3, Nanopriming with ZnO Nanoparticles and Biopriming with bioagent *T. harzianum* and *P. fluorescens* under three replications*.* After priming, the seeds, effect of different priming methods on field emergence and subsequent morpho-phenological and yield characters in *boro* season was tested, followed by seed quality parameters in offseason planting. The efficacy of priming treatments for mitigation of cold stress during early vegetative and reproductive stage of rice and also control of disease in rice was evaluated. The result confirmed that three priming techniques used in this study *viz.*, Nanopriming, Biopriming & hormonal priming were very effective as it showed a positive effect on seed performance along with more than 85% germination under cold stress.

P.21: Food Security vs Plant Diseases: An Indian perspective

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Food insecurity is a "silent emergency" globally. The status of food security in an agro-based developing country like India is complex yet a sustainable developmental issue. The development policies of agriculture in India post independence have emphasized on reducing poverty, hunger and food insecurity. The component of food security includes food availability, physical and economic access to food, and food utilization like nutritive value, food safety, as has been recently reviewed. Plant protection and the protection of crops against plant diseases, have an obvious role to play in balancing the growing demand and supply of food quality and quantity. Pathogens are one of the major causes of losses which may be direct as well as indirect. Roughly, direct yield losses caused by pathogens range between 10 to 12.5 per cent of global agricultural productivity, while in India it accounts for 15 to 30 per cent loss in production. Crop losses occurring as a result of pests and pathogens may be direct as well as indirect. They have a number of dimensions, some with short, and others with long-term consequences. Thus, losses caused by plant disease directly affect the components of food security or indirectly through the fabrics of trade, policies and societies. Plant diseases can not only devastate natural ecosystems, intensifying environmental degradation but also pose threat to the consumers. Crop loss due to diseases in terms of yield and productivity can mean that communities become more dependent on imported foods, often replacing a balanced diet with processed foods, posing further health hazards. Priority has to be assigned to agriculture and food security related issues along with crop protection measures so as to mitigate crop losses. As the problem is multi-dimensional so the solution needs to be multi-sectoral.

P.22: Antagonistic and plant growth promotion activity of *Trichoderma* isolates against *Fusarium oxysporium* f. sp. *lentis*

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The biological control activities of 12 isolates of *Trichoderma* spp were tested against 30 isolates of *Fusarium oxysporium* using dual culture, as well as volatile and non-volatile techniques. Maximum percent inhibition of radial growth (PIRG) was found in *T. hazianum* (5593)(82.4%), *T. harzianum* (ThL-4) (80.6%) and *T. asperellum* (TaL-2) (80.0%) using dual culture method. Volatile and non-volatile assay (25% and 50% v/v concentration) revealed that the *Trichoderma* strains 5593, T-4 and T-2 produced 90 to 100% inhibitory effect in volatile and in non- volatile assay with 65% (v/v) concentration. The mechanism of action of *Trichoderma* spp. was observed microscopically by using Scanning Electron Microscope (SEM) and found coiling structure of *Trichoderma* mycelium over *Fusarum* mycelium for controlling the growth of *Fusarium*. The selected isolates (5593, ThL-4 and TaL-2) of *Trichoderma* were further evaluated for their plant growth promotion activity and yield under field condition using resistant (L-4147) and susceptible (vidhohar local) cultivars. They were found effective in seed germination, increased biomass, increased root and shoot length, reduced wilt incidence, produced more number of nodules for nitrogen fixation and highest total yield. Here, it might be stated that isolates 5593, ThL-4 and TaL-2 are among the effective biocontrol agents against Fusarium wilt and can be used as formulated biofungicides in reducing wilt disease in lentil.

P.23: Eco-friendly approaches to alleviate the disease in seedlings caused by *Pythium* sp., in Faizabad district of Uttar Pradesh, India

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Majority plants are cultivated from seeds, and for high yield the establishment of healthy and uniform stands of vigorous seedlings at optimum densities are required. If not cared, nursery diseases may either kill the seedlings or debilitate the plants which lead to poor growth and increased susceptibility to other stresses. Plant diseases caused by *Pythium* are divided in two types; diseases that affect plant parts in contact with the soil (roots, lower stem, seeds, tubers, and fleshy fruits) and diseases that affect above ground parts (leaves, young stems, and fruits). None of the single approaches may be safe and effective to alleviate the problem with greater sustainability as healthy plants are more able to resist diseases. Effect of soil solarisation using TPE 0.05 mm for 40 days enhanced the highest seed germination (95.0%), root length (50.2%) and shoot length (65.7%) with a vigour index of 67.0%. Interestingly, it was noticed that 130 µm polythene thicknesses was better than 80 µm in reducing the total fungal pathogen population and increasing seedling stands. Some known antimicrobial plant extracts were used to control the pathogen. Of the tested phytoextracts, *Ocimum sanctum* extract was found to highly inhibit the against *Pythium* sp. As biocontrol agent a few strains of *Trichoderma* spp. were used, but the significant disease reduction was registered in seedlings treated with *T. harzianum* S (9.3%), *T. harzianum* M (20.2%) and *T. harzianum* A (19.8%), respectively. The minimum pre-emergence seedling mortality was achieved after the solarisation and seed treatment with *Trichoderma harzianum* @ 4g/kg seed, followed by solarisation + seed treatment with carbendazim, Thiram, and Dithane M-45. The mortality recorded in solarised plot was 31.85%, where as it was 46.88% in the control. The minimum pre-emergence mortality was observed in application of SS + ST with *T. harzianum* (19.24%) followed by SS + ST with Carbendazim and SS + ST with Thiram showing 20.06 and 22.04 percent respectively.

P.24: Antifungal attributes of phosphate solubilizing *Burkholderia* sp. VIMP04 (JQ867373) against soil-borne fungal pathogens of sugarcane

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The objective of the present study was to investigate antifungal features of *Burkholderia* sp. VIMP04 (JQ867373), a phosphate solubilizing isolate from sugar beet rhizosphere by dual culture and agar well diffusion methods against soil-borne pathogens *Ceratocystis paradoxa* and *Alternaria alternata.* Both pathogens are the causative agents of pineapple and leaf spot diseases of sugarcane, respectively. Present bacterial culture solubilized tri-calcium phosphate and rock phosphate and produced 71.8 % and 32.4% soluble phosphorus (P). Culture filtrate and ethyl acetate extract obtained from culture supernatant of *Burkholderia* sp. VIMP04 (JQ867373) showed prominent antifungal activity. HPLC analysis confirmed presence of different organic acids including acetic, oxalic and formic acids. Acetic acid was predominantly produced by the culture under study (42.75mg %). The GC-MS analysis of ethyl acetate extract revealed that antifungal fractions contained about 09 compounds including tetratetracontane, 10-Heneicosene, eicosene 7-hexyl, cyclopentane 1, 1- dodecylidenebis (4-methyl), cyclohexane (6-cyclopentyl-3-(3-cyclopentylpropyl) hexyl, heptadecane 9-hexyl and other fatty acid-, alcoholic- and phthalic acid derivatives. Hence the culture under study can be used as biocontrol agent.

P.25: Biodiversity conservation and phylogenetic systematics of twenty *Aspergillus* species of India

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The genus *Aspergillus* is known for its diverse actions *viz*., as plant and human pathogen, as post harvest pathogen of fruits and vegetables and also as potent biocontrol organism (*A. niger* as Kali sena). Thirty isolates of *Aspergillus* were obtained from various geographical locations of India and were subjected to phenotypic evaluation and made in to 20 different species *viz. A. flavus, A. parasiticus, A. niger, A. sulphureus, A. sydowi, A. quadrilineatus, A. puniceus, A. ustus, A. terricola, A. terreus, A. funiculosus, A. niveus, A. clavatus, A. aculeatus, A. nidulans, A. amstelodami, A. fischeri, A. fumigatus, A. versicolor* and *A. japonicus* based on cultural and microscopic characters. Species identifications based on only morphology may be sometimes erroneous, uncertain or remain unclear due to overlapping characters. Therefore, molecular characterisation based on ITS was performed for reliable identification and *ß-tub* for their phylogenetic relationship. The *ß-tub* gene has clearly differentiated all the 20 species of *Aspergillus* whereas ITS region could not segregate all the species accurately. The morphological characters *viz.,* colony, conidiophores, phialides, conidia and chlamydospores of all the 20 species of *Aspergillus* were described along with microphotographs. The ITS and *ß-tub* gene sequences of all the species studied have been deposited in the Genbank.

P.26: Identification of wild mushroom from West Bengal using molecular markers

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Pleurotus spp. constitute one of the choicest edible mushrooms, it is commonly known as Oyster mushroom. The genus *Pleurotus* has important medicinal, biotechnological and environmental applications. *Pleurotus* spp are highly preferred in regions of West Bengal. The concept of naming species on the basis of morphological characteristics has been dominant in the fungal taxonomy. However, morphological features of higher fungi are largely inconsistent as they are strongly influenced by the cultivation substrate and environmental conditions. Consequently, different taxonomists have given different concepts and conclusions for the same taxon on the basis of morphological features. There are confusions in classifying *Pleurotus* isolates using only morphological characters which are often unreliable and inconclusive mainly due to the large influence exerted by environmental factors. Population structure analysis using morpho-cultural traits of an individual is not reliable procedure, distinction of which requires expertise. To overcome this limitation, molecular /DNA based markers have proved very useful in investigating the genetic diversity of fungal organisms. Mycelial cultures of three species of *Pleurotus viz*., *P. ostreatus, P. sajor-caju* and *P. florida* were procured from Directorate of Mushroom Research (DMR), Solan (HP) and one was collected wild from Bankura district of West Bengal during the monsoon months of 2017-18. Thus a total of four species/strains were taken for further studies. Genomic DNA isolated from the broth culture of fungal isolates was subjected to polymerase chain reaction for amplifying internally transcribed spacer (ITS) region. PCR amplification showed single amplified band of ~700 bp in all isolates of *Pleurotus*. The ITS amplified region of fungal DNA was sequenced and a 515 bp sequence was found. The sequence was analyzed using BLASTn programme. The analysis showed a homology of 94% to *Xylaria* spp. which is pointing to a different observation in comparison to our morphological studies. Though, there has always been ambiguity in the fungal taxonomy which is predominantly based on the morphological markers but the molecular markers in today's era has reduced such confusion leading to authentic identification of mushroom species. Morphological characteristics showed it could be a *Pleurotus* spp. which are consumed by the local people but the molecular studies have led to a different output. So, there is a need to use more molecular markers in order to ascertain the identity of this wild mushrooms correctly. Further, development of species specific markers will help in identifying the edible species which can mitigate the deaths due to consumption of poisonous mushrooms.

P.27: Impact of soil-applied mineral nutrients (NPK fertilizers) on the incidence of tea mosquito bug (TMB), *Helopeltis antonii* Signoret (Heteroptera: Miridae) and its induced foliar disease infection in clonal cashew orchards in the Northeastern Tamil Nadu, India

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Cashewnut (*Anacardium occidentale* Linn.), a high-value commercial crop of India, is largely grown in marginal soils of dry-land belts. The realized nut yields are usually considerably lower than potential yield, largely due to depletion of available soil nutrients coupled with vulnerability of stressed plants to pest and disease manifestations. Reinforcing soil fertility through supplementation of mineral nutrients may help to mitigate pest and disease manifestation induced under stress caused by nutrient loss in soil. Keeping the aspects in view, studies were conducted at the AICRP Experimental Farm of Tamil Nadu Agricultural University, Regional Research Station, Vridhachalam, Tamil Nadu, India from 2003 to 2013 on the influence of nine different NPK fertilizer rates at nitrogen (N) (0, 500 and 1000g/tree), phosphorus (P) (0, 125 and 250g/tree) and potassium (K) (0, 125 and 250g/tree), each consisted of three sub-components in twenty seven treatment combinations on the incidence of tea mosquito bug (TMB), *Helopeltis antonii* Signoret (Heteroptera: Miridae) and its induced infections of foliar diseases on five years old VRI-2 clonal cashew orchard. Results showed that soil application of nitrogen higher than the recommended doses sharply increased the population of *H. antonii* and induced the manifestation of foliar disease infection. Higher levels of phosphorus and potassium nutrients, on the other hand, alone and in combination decreased the population of *H. antonii* and disease manifestations across the study period. Increased doses of phosphorus and potassium applied in soil also increased nut yield significantly each year. The increased nut yield obtained with increased levels of phosphorus and potassium might be due to reduced population of *H. antonii*, where as the higher yield resulting from combination of NPK nutrients might be due to increased plant vigour, which resulted in withstanding capacity of plant to tolerate manifestation of pests without affecting the yield of nuts.

P.28: Studies on IPM technology demonstration for sustainable and safe mango production in Tumakuru district of Karnataka

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Increased environmental awareness has led to the need for sustainable agricultural production systems. IPM becomes essential component of sustainable agriculture. The integration of the various control measures, where pesticides are used only as a last resort, ensures that pests remain below the economic threshold, thus supporting sustainable production, food safety and international market access. A study was conducted to demonstrate this IIHR developed IPM technology for control of both pests and diseases in mango in consecutive two years during 2015-16 and 2016-17. The studies were mainly concentrated on two major diseases *viz.,* powdery mildew, anthracnose and pests *viz.,* plant hoppers, fruit flies which are prevalent and cause severe yield loss in Tumakuru district. IPM technology includes spraying of botanical pesticides, use of fruit fly trap and hot water treatment etc. Results revealed that the incidence with respect to both pests and diseases significantly varied with the control orchard. Powdery mildew incidence was ranging from 6.68-8.95 per cent in demonstrated orchard compared to 28.78 per cent in control orchard. Anthracnose severity on fruits was decreased to an extent of 58.83 per cent demo orchard over control. Demo orchard recorded the decreased fruit fly infestation of 8.66 per cent as against 38.13 per cent in control orchard due to cent percent adaption of IPM practices as taught by KVK scientists. An average yield of 54.60 per cent and quality fruits as well observed under demonstration orchards, as compared to farmers' traditional ways. Wide technology gaps were observed in both the years, the lowest (1.04 tonnes/ ha) and the highest (3.02 tonnes/ha) in the year 2015-16 and 2016-17, respectively. On two years average basis, technology gap of total 20 demonstrations was observed as 2.38 tonnes per hectare. The higher additional returns and effective gain obtained under demonstrations could be due to potentiality of the IPM technology in controlling both the pests and diseases. The average Benefit : Cost ratio was 4.35 and 2.80 in demo and control orchards, respectively. It is also evident that consistent supply was ensured. This makes significant difference in getting the good price compared to the previous years. Farmers were also extremely satisfied as the IPM technology facilitated in getting more demand of their produce due to fruti quality particularly size, texture, shape, uniform ripening and assured chemical free production.

P.29: Significance of rice sheath blight in India and its management through host plant resistance/tolerance

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India is the largest rice grower, consumer and exporter. After the introduction of green revolution, sheath blight caused by *Rhizoctonia solani* has became as one of the major constraints for rice production and it causes yield loss up to 70-80%. To address this problem studies have been initiated to understand the disease scenario across the India, pathogen population dynamics, identifying the resistant source and selecting effective fungicides to manage the disease. The IIRR-Production Oriented Survey (POS) data of 35 years (1981-2016) was used to generate district wise sheath blight disease maps of India by using ArcMap software. Disease has been increased in terms of both intensity and severity over the past 20 years in all rice ecosystems. At present, it is a major production constraint in Indo-Gangetic plains, East coast, West coast and parts of central plains in India. About 120 Sheath blight pathogen isolates were collected from across India and purified. All these isolates were characterized through phenotyping, pathotyping and genotyping. During the last two decades (2000-2017), about 20,000 breeding lines and germplasms were evaluated under All India Co-ordinated Rice Improvement Project (AICRIP) for sheath blight resistance. However, only few lines with moderate level of resistance were identified. Besides, about 7000 germplasm, wild rice and land races were also screened under artificial condition at ICAR-IIRR. Among these four lines *viz*., Gumdhan, Wazuhophek, Ngonolasha and Phougak were identified with good level of resistance. In multi-location testing Wazuhophek performed better than tolerant check (Tetep). The expression rate of selected defence related genes in two cultivars *i.e.,* Whazhuophek as tolerant and IR-50 as susceptible were studied. The expression transcripts of defence related genes *viz.,* PR-1, PR-2, PR-3, PR-4, PR-5, PR-9, PR-10, PR-13, CHS, LOX, PAL and PPO were studied by using quantitative Real-time PCR (qRT PCR). Results showed that the expression rate of 9 out of 12 investigated genes were higher in tolerant cultivars than susceptible. The expression levels of PR-1, PR-3, PR-9 and PR-10 genes were 56.14%, 95.85%, 31.48%, and 66.1% higher folds in Whazhuophek than IR-50 at 72 hours after inoculation with *R. solani*. Crosses were made between Improved Sambha Mahsuri (ISM)/Wazuhophek to develop a RIL population for characterising sheath blight resistance. The RIL population of ISM/Wazuhopehk (F8 stage) was artificially screened. Out of 330 F_7 and F_8 lines, seven lines were identified with good level of resistance for two seasons.

P.30: Seed borne fungi associated with soybean

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Soybean (*Glycine max*) crop is attacked by a variety of seed and soil borne fungal pathogens as well as other pathogens. Therefore, present investigation was planned to study the association of seed borne fungi of soybean. The seed samples of four different varieties were collected to study the seed borne mycoflora. Eight different types of fungi were associated with seed were detected by following standard blotter paper method, 2, 4-D blotter method and agar plate method. All together, eight fungi comprising *Aspergillus niger, A. flavus, Fusarium oxysporum, Colletotrichum dematium, Rhizoctonia bataticola, Curvularia lunata, Alternaria alternata* and *Rhizopus stolonifer* were observed in all seed detection methods. The difference in methods of recording fungi was also significant and standard blotter paper method was most efficient in recording more number of fungal colonies.

P.31: Evaluation of fungicides and botanicals against major seed borne fungi of groundnut

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In vitro investigation was carried out to assess the efficacy of five fungicides and five botanicals against major seed borne fungi of groundnut. All the fungicides and botanicals exhibited significant mycelial growth inhibition of six major seed borne fungi *viz.*, *Aspergillus flavus, Aspergillus niger, Fusarium oxysporum, Rhizoctonia bataticola, Sclerotium rolfsii* and *Alternaria alternata* of groundnut. However, the fungicides *viz*., Carbendazim 50% WP, Carbendazim 12% + Mancozeb 63% WP, Carboxin 37.5% + Thiram 37.5 % WS, Captain 70% + Hexaconazole 5% and Thiophanate methyl 450 g/l + Pyraclostrobin 50 g/l FS and botanicals *viz*., *Azadirachta indica* (Leaf extract), *Allium sativum* (Clove extract), *Ocimum sanctum* (Leaf extract), *Curcuma longa* (Rhizome extract) and *Zingiber officinale* (Rhizome extract) significantly arrested the radial mycelial growth of all pathogens. These fungicides inhibited 100 per cent growth of *A. flavus, A. niger, F. oxysporum, R. bataticola* and *S. rolfsii.* Among the botanicals, *Allium sativum* showed 100 per cent growth inhibition in all these pathogens. Rests of botanicals were also found equally effective.

P.32: Prevalence and distribution of *Ascochyta rabiei* in India and identification of resistance sources

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Ascochyta blight (AB), caused by the fungus *Ascochyta rabiei* (Pass.) Labr., is a major constraint for chickpea production in India and worldwide, causing 50-100 per cent loss under severe infection. It occurs frequently where cool and humid weather prevailing for substantial time during the crop season. A survey was conducted to know the prevalence and distribution of Ascochyta blight in major chickpea growing regions of Punjab, Jammu, and North Rajasthan of North Western Plain Zone (NWPZ) and also Uttarkhand, Eastern Uttar Pradesh of India in the *rabi* season of 2016-17 and 2017-18. During the year 2016-17, only 4-10 per cent incidence was observed with negligible severity on cultivars L-550, GPF 2, GNG series and local desi types in Punjab, Jammu and Uttarkhand states of Northern India. During the year 2017-18, 2 per cent (PBG 7) to 100 per cent (L-550) incidence was observed at Ludhiana and upto 50 per cent disease severity was observed in Gurdaspur as compared to < 2 per cent in other districts of Punjab. The major cultivars cultivated in Punjab are PBG 5, PBG 7 and GPF 2 which are mainly tolerant to AB. In Samba region of Jammu and Kashmir state observed only 2-3 per cent incidence with less or negligible disease severity. Sri Ganganagar district of Rajasthan observed no AB in both the years. In Udam Singh Nagar and Nainital districts of Uttarkhand observed 2-5 per cent AB in all the chickpea growing fields of Uttarkhand state. To control AB disease, disease screening was conducted to identify the resistance sources against *A. rabiei*. A total of 380 chickpea cultivars/lines and NBPGR germplasm were screened under controlled environmental facility (CEF) where, leaf wetness up to 72 hours after inoculation and 70-80 per cent relative humidity were maintained during the subsequent 12 days. Among 380 genotypes, only 15 cultivars/lines, namely GNG 1958, GNG 1969, GNG 469, Himachal Channa-1, HC 5, GNG 1581, ILC 482, ILC 3279, NBeG 440, PBG 5, IPC 2005-15, IPC 2005-45, IC 2792, IC 83129 and IC 117744 were showed resistant reaction. The information generated from survey might be useful for farmers to grow resistant cultivars as a precautionary measure to prevent the loss caused by the disease in the frequently occurring areas and resistant sources are helpful for plant breeders to develop resistant cultivars against AB of chickpea.

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