Regional Conference on

Role of Soil and Plant Health Towards Achieving Sustainable Development Goals (SDG) in Asia-Pacific

21-23 November 2018

Bangkok, Thailand

Proceedings and Recommendations

Australian Government

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Regional Conference on

ROLE OF SOIL AND PLANT HEALTH TOWARDS ACHIEVING SUSTAINABLE DEVELOPMENT GOALS (SDG) IN ASIA-PACIFIC

November 21-23, 2018, Bangkok, Thailand

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Contents

Foreword

The human activities to grow more food and fodder especially during the past century, misused and overused soils that led to high degradation of 25% of earth's land is a matter of concern. Sustainable use of terrestrial ecosystems and reversing land degradation is part of Sustainable Development Goal (SDG) 15 of the United Nations. FAO's initiatives in this area such as Global Soil Partnership and the Asia Soil Partnership at regional level are extremely important. Soil and plant health and the environment in which they sustain are interrelated and need to be addressed comprehensively and not in isolation.

At this juncture, this APAARI initiative of sensitising member countries through a regional conference to review the status of soil and plant health and to orient the region in line with global initiatives is very timely in this 'International decade of soils (2015-2024) and the proposed 2020 as 'International year of plant health'. I sincerely appreciate ACIAR, COA, Taiwan, ICRISAT, IRRI, Department of Agriculture, Thailand and Indian Phytopathological Society (IPS) for coming forward to be the coorganisers of the Regional Conference on 'Role of Soil and Plant Health Towards Achieving Sustainable Development Goals' at Bangkok , Thailand from 21-23 November, 2018. Participation of APAARI members with status reports, international experts in the domains of soil and plant health within the region and across the globe guiding the programme along with a large number of IPS members made this conference very lively and comprehensive.

The technical sessions in this regional conference covered wide range of subjects within the ambit of soil and plant health that include regional initiatives and priorities; climate change, sustainability and value chain; knowledge management, outreach and commercialisation; eco-friendly approaches for management; quarantine, diagnosis, taxonomy and biodiversity; case studies on plant health management;research trends in plant health management and a panel discussion on policy and capacity development on soil and plant health.

A large number of country representatives and experts covered the subject of the regional conference and the discussions were summarised as recommendations. Participation of FAO both from Head Quarters and the Regional Office was of great relevance to align the member countries to the global initiatives. The action points listed in this Proceedings and Recommendations of the Regional Conference on Soil and Plant Health Towards Achieving Sustainable Development Goals in Asia-Pacific are in the direction of achieving the SDGs relevant to the theme. I appreciate the APAARI Secretariat, Consultants and other experts who conducted the conference in a well structured manner on the most important and relevant topic for the region. I also appreciate the editorial team for bringing out the Proceedings and Recommendations. I wish that APAARI and its members strive hard to implement the recommendations to mitigate the adverse effects of soil and plant health in the context of changing climate scenario moving the Asia-Pacific Region to achieve the SDGs by harmonising with the global initiatives.

Dr. Ravi Khetarpal
Executive Secretary - APAARI

Acknowledgements

APAARI is thankful to the Co-Organisers, Council of Agriculture (COA), Taiwan, Australian Centre for International Agricultural Research (ACIAR), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Rice Research Institute (IRRI), Indian Phytopathological Society (IPS) and Department of Agriculture (DOA), Thailand for their whole hearted support to the Regional Conference on 'Role of Soil and Plant Health Towards Achieving Sustainable Development Goals in Asia Pacific held on 21-23 November 2018 at Bangkok, Thailand.

I am extremely grateful to HE Luck Wajananawat, Deputy Minister of Agriculture and Cooperatives, Thailand for accepting to be the chief guest and to HE Chen-Yuan Tung, Representative, TECO, Thailand for his participation in the inaugural session. We are thankful to DOA, Thailand for deputing Warawut Chootummatouch, FAO Regional Office for the Asia and the Pacific for deputing Louise Whiting and FAO Head Quarters for deputing Yuxin Tong. We also thank Dr RN Pandey, IPS for his support and encouragement to a large number of plant health experts participation in the conference. Our sincere thanks are due to the chairs, co-chairs, rapporteurs, panelists, speakers, discussants and participants for their contributions.

Efforts of member countries in preparation of status reports and active participation in the conference is highly appreciated. We are thankful to all the invited experts from wide range of fields across the globe including region, for their participation and contributions. I would like to acknowledge Dr CL Acharya and Dr KS Varaprasad for their support right from the concept note to the preparation of proceedings of this conference. Efforts of editorial team is appreciated. I also thank Dr EVSP Rao, Consultant and ex-Chief Scientist and Advisor, CSIR- Fourth Paradigm Institute (4PI), India for his review and comments on the draft Proceedings and Recommendations.

I acknowledge the great support of APAARI Secretariat for their committed and untainted support not only in the logistic support but also in communication and preparation of the manuscript on Proceedings and Recommendations. Special thanks are due to Mr Vishwanath K Sah for his contributions in preparation of electronic version in PDF format of this Proceedings and Recommendations. Dr RK Tyagi's support and contributions in conducting this Regional Conference is thankfully acknowledged. I hope that all the APAARI members, having reviewed the status of soil and plant health of their respective countries, shall take the advantage of this Proceedings and Recommendations and align with the global initiatives. APAARI is committed to follow up the recommendations emerged out of the Conference and help the Asia-Pacific Region moving towards achieving Sustainable Development Goals by improving the soil and plant health under changing climate scenario.

Dr. Ravi Khetarpal
Executive Secretary - APAARI

The Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)

The Asia-Pacific Association of Agricultural Research Institutions (APAARI), with its headquarters in Bangkok, is a unique voluntary, membership-based, self-mandated, apolitical and multi-stakeholder regional organization in the Asia-Pacific region. It promotes and strengthens agriculture and agri-food research and innovation systems through partnerships and collaboration, capacity development and advocacy for sustainable agricultural development in the region. Since its establishment in 1990, APAARI has significantly contributed towards addressing agricultural research needs and enhancing food and nutritional security in the region. The close links, networks, partnerships and collaboration with stakeholders that APAARI has developed over the years, as well as its goodwill, authority and focus on results, make the Association an important actor in the region. The ultimate aim of APAARI is to help realizing sustainable development goals in Asia and the Pacific. Please visit https://www.apaari.org

Department of Agriculture, Thailand (DOA)

The Department of Agriculture (DOA) was established since October 1, 1972 under the Revolutionary Decree No. 216 dated September 29, 1972 by merging the former Department of Agriculture and the Rice Department. The union was aimed to facilitate coordination among the Departments and officers as well as to streamline its function to enable a more efficient implementation of is mandates. The 15 pioneering units of the Department of Agriculture were the Office of the Secretary, Finance Division, Personnel Division, Planning Division, Rice Division, Field Crops Division, Horticulture Division, Sericulture Division, Rubber Division, Agricultural Engineering Division, Plant Pathology Division, Entomology and Zoology Division, and Agricultural Chemistry Division, a total of 95 research centres, stations and plant quarantine stations were then established throughout the country. For more information, please visit: www.doa.go.th/en/

Council of Agricultural, Taiwan (COA)

The Council of Agriculture (COA), Taiwan is the competent authority on the agricultural, forestry, fishery, animal husbandary and food affairs in Taiwan. Its responsibilities include guiding and supervising provincial and municipal offices in these areas. Under the council, there are Department of Planning, Department of Animal Industry, Department of Farmers' Services, Department of International Affairs, Department of Science and Technology, Department of Irrigation and Engineering, Secretariat, Personnel Office, Accounting Office, Civil Service Ethics Office, Legal Affairs Committee, Petitions and Appeals Committee and Information Management Center respectively in-charge of related affairs.
Please visit http://eng.coa.gov.tw

Australian Government
Australian Centre for International Agricultural Research

Australian Centre for International Agricultural Research (ACIAR)

As Australia's specialist international agricultural research for development agency, our purpose is to broker and fund research partnerships between Australian scientists and their counterparts in developing countries. As world leaders in agricultural research, Australian scientists are encouraged and supported to use their skills for the benefit of partner countries while at the same time contributing to solutions to meet Australia's own agricultural challenges. The diversity of our own agriculture sector, which extends from the tropics to the arid zone, continues to thrive while operating in highly variable and challenging cli- mates with minimal external subsidies. This suggests the Australian agricultural sector has valuable knowledge and expertise to share with other countries facing similar challenges, including farmers, rural poor, consumers, researchers and policymakers. Since 1982, ACIAR has supported research projects in four regions—eastern and southern Africa, East Asia, South and West Asia and the Pacific. Our research projects focus on crops, agribusiness, horticulture, forestry, livestock, fisheries, water and climate, social sciences, and soil and land management. They deliver specific development outcomes. To date, ACIAR has commissioned and managed more than 1,500 research projects in 36 countries, partnering with 150 institutions along with more than 50 Australian research organisations. For more information, please visit https://www.aciar.gov.au

The Indian Phytopathological Society (IPS)

The Department of Agriculture (DOA) was established since October 1, 1972 under the Revolutionary The Indian Phytopathological Society (IPS) is a professional society for promoting the cause of science of Phytopathology. The Society focuses in the field of Mycology, Plant Pathology, Bacteriology, Virology, Phytoplasmology and Nematology. It provides a unique platform to the scientists working in the field of plant pathological related research to share their research achievements. It also keeps members informed the various activities related to the development of plant pathology and about the members of the society. Objectves of the IPS are: To advance the cause of Mycology and Plant Pathology in India; To encourage and promote mycological and plant pathological studies and research in the country; To disseminate the knowledge of mycology and plant pathology; and To facilitate closer association and relations among members and other scientific workers in India and abroad. The Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi would be the permanent Headquarters of the Society. For more information please refer to http://www.ipsdis.org.

International Rice Research Institute (IRRI)

The International Rice Research Institute (IRRI) is the world's premier research organization dedicated to reducing poverty and hunger through rice science; improving the health and welfare of rice farmers and consumers; and protecting the rice-growing environment for future generations. IRRI is an independent, nonprofit, research and educational institute, founded in 1960 by the Ford and Rockefeller foundations with support from the Philippine government. The institute, headquartered in Los Baños, Philippines, has offices in 17 rice-growing countries in Asia and Africa, and more than 1,000 staff. Working with in-country partners, IRRI develops advanced rice varieties that yield more grain and better withstand pests and disease as well as flooding, drought, and other harmful effects of climate change. More than half of the rice area in Asia is planted to IRRI-bred varieties or their progenies. The institute develops new and improved methods and technologies that enable farmers to manage their farms profitably and sustainably, and recommends rice varieties and agricultural practices suitable to particular farm conditions as well as consumer preferences. IRRI assists national agricultural research and extension systems in formulating and implementing country rice sector strategies. IRRI is a member of the CGIAR Consortium, a global research partnership committed to a food-secure future.The Institute is the lead center for the CGIAR Research Program on RICE (RICE CRP). For more information please visit https://www.irri.org

International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT)

The International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) is a non-profit, non- political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics are home to over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT and its partners help empower these poor people to overcome poverty, hunger and a degraded environment through better agriculture. ICRISAT is headquartered near Hyderabad, Telangana State, India, with two regional hubs and four country offices in sub-Saharan Africa. It belongs to the Consortium of Centers supported by the Consultative Group on International Agricultural Research (CGIAR).
For more information, please visit: www.icrisat.org

Acronyms and Abbreviations

ABTV	*Abaca bunchy top virus*
ACC	1-Aminocyclopropane-1-Carboxylic Acid
AFOLU	Agriculture, Forestry and Other Land Uses
AI	Artificial Intelligence
AICRP	All India Coordinated Research Project
AIRCA	Association of International Research and Development Centers for Agriculture
AMF	Arbuscular Mycorrhizal Fungi
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APPPC	Asia and Pacific Plant Protection Commission
APX	Ascorbate Peroxidase
AREEO	Agricultural Research, Education and Extension Organization
ASEAN	Association of Southeast Asian Nations
ASEAN-GSNM	Association of Southeast Asian Nations-Guidelines on Soil and Nutrient Management
ASIS	Asian Soil Information System
ASP	Asian Soil Partnership
BAR	Bureau of Agricultural Research
BARI	Bangladesh Agricultural Research Institute
BBrMV	*Banana bract mosaic virus*
BBTV	*Banana bunchy top virus*
BCAs	Biocontrol Agents
BLSB	Banded Leaf and Sheath Blight
BOLD	Barcode of Life Data System
BPH	Brown Plant Hoppers
BSV	*Banana streak virus*
BYMV	*Bean yellow mosaic virus*
CA	Conservation Agriculture
CABI	Centre for Agriculture and Bioscience International
CalMVV	*Calanthe mild mosaic virus*
CAT	Catalase
CATAS	Chinese Academy of Tropical Agricultural Sciences
CBD	Convention on Biological Diversity
CEC	Cation Exchange Capacity
CEF	Controlled Environmental Facility
CESRA	Center of Excellence for Soil Research in Asia
CIBRC	Central Insecticide Board and Registration Committee
CF	Culture Filtrates
CFU	Colony Forming Units
CGD	Citrus Greening Disease
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIRAD	French Agrultural Research Center for International Development
CLCuBuA	Cotton leaf curl Burewala alphasatellite
CLCuD	Cotton Leaf Curl Disease
CLCuKoV	*Cotton leaf curl Kokhran virus*
CLCuMA	Cotton leaf curl Multan alphasatellite
CLCuMB	Cotton leaf curl Multan beta-satellite
CLCuMuV	*Cotton leaf curl Multan virus*
CrYVMoA	Croton yellow vein mosaic alphasatellite
CMBP	Common Microbial Biotechnology Platform

Acronyms and Abbreviations *(cont..)*

CMV	*Cucumber mosaic virus*
COA	Council of Agriculture
CPB	Cartegena Protocol on Biosafety
CPF	Crop Protection Federation
CRIDA	Central Research Institute for Dryland Agriculture
CrYVMoA	Croton yellow vein mosaic alphasatellite
CTAB	Cetyl Trimethyl Ammonium Bromide
CUSAR	Chulalongkorn University School of Agricultural Resources
CymMV	*Cymbidium mosaic virus*
CymRSV	*Cymbidium ringspot virus*
DAC-ELISA	Direct Antigen Coating-Enzyme-linked Immunosorbent Assay
DAC&FW	Department of Agriculture, Cooperation & Farmers Welfare
DARE	Department of Agricultural Research and Education
DAS-ELISA	Double Antibody Sandwich-Enzyme-linked Immunosorbent Assay
DAT	Days After Transplanting
DOA	Department of Agriculture
DM	Downy Mildew
DNA	Deoxyribonucleic Acid
DSS	Decision Support System
ELISA	Enzyme-linked Immunosorbent Assay
EMPRES	Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases
FAO	Food and Agriculture Organization
FAW	Fall Armyworm
FFS	Farmer Field schools
FS	Foliar Spray
FTIR	Fourier-transfoem Infrared
GAP	Good Agricultural Practices
GBNV	*Groundnut bud necrosis virus*
GHGs	Green house Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GKMS	Gramin Krishi Mausam Sewa
GRET-ALiSEA	GRET-Agroecology Learning alliance in South East Asia
GDarSLA	Gossypium darwini symptomless alphasatellite
GLASOD	Global Assessment of Human-Induced Soil Degradation
GLOSIS	Global Soil Information System
GLOSOLAN	Global Soil Laboratory Network
GMO	Genetically modified Organism
GMP	Good Manufacturing Practices
GPDH	Glyceraldehyde-3-Phosphate Dehydrogenase
GSP	Global Soil Partnership
HAERE	Higher Agriculture Education, Research and Extension
HCIO	Herbarium Cryptogamae Indiae Orientalis
HCN	Hydrogen Cyanide
HEIs	Higher Education Institutions
HLB	Huanglongbing
HR	Hypersensitive Response
IAA	Indole-3-acetic acid
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research

Acronyms and Abbreviations *(cont..)*

IC-PCR	Immunocapture-PCR
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IDM	Integrated Disease Management
IF	Isolation Frequency
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IIHR	Indian Institute of Horticultural Research
IIRR	Indian Institute of Rice Research
IISR	Indian Institute of Spices Research
IIT	minimum inhibitory concentrations
INBS	International Network of Black Soils
INM	Integrated Nutrient Management
INSII	International Network of Soil Information Institutions
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IPS	Indian Phytopathological Society
IRB	Indole Acetic Acid Producing Rhizobacteria
IRRI	International Rice Research Institute
IRRI-SARC	International Rice Research Institute-South Asia Regional Centre
ISM	Improved Sambha Mahsuri
ISSR	Inter Simple Sequence Repeats
ITCC	Indian Type Culture Collection
ITPS	Intergovernmental Technical Panel on Soils
ITS	Internal Transcribed Spacer
IUSS	International Union of Soil Science
JA	Jasmonic Acid
JIRCAS	International Research Center for Agricultural Sciences
KM	Knowledge Management
KU	Kasetsart University
KVK	Krishi Vigyan Kendra
LAMP	Loop Mediated Isothermal Amplification
LMO	Living Modified Organism
LSU	Large Subunit
MAF	Ministry of Agriculture and Fisheries
MARD	Ministry of Agriculture and Rural Development
MARDI	Malaysian Agricultural Research and Development Institute
MBIM	Mycelial Bit Inoculation Method
MDGs	Millenium Development Goals
MICs	Minimum Inhibitory Concentrations
MLR	Multiple Linear Regression
MOOCS	Massive Open Online Courses
MPUAT	Maharana Pratap University of Agriculture and Technology
MRIIRS	Manav Rachna International Institute of Research and Studies
MRL	Maximum Residue Limit
MyGAP	Malaysia Good Agricultural Practices
Myorganic	Myorganic
NAFRI	National Agriculture and Forestry Research Institute
NARC	Nepal Agricultural Research Council
NARI	National Agricultural Reseach Institute

Acronyms and Abbreviations *(cont..)*

NCBI	National Center for Biotechnology Information
NBPGR	National Bureau of Plant Genetic Resources
NBS	Nutrient Based Subsidy
NGO	Non-Governmental Organisation
NICRA	National Innovations in Climate Resilient Agriculture
NPO	Non-Profit Organisation
NPPO	National Plant Protection Organisation
NPs	Nanoparticles
NRRI	National Rice Research Institute
NUE	Nitrogen Use Efficiency
OC	Organic Carbon
OFV	*Orchid fleck virus*
OM	Organic Matter
ORSV	*Odontoglossum ringspot virus*
PAL	Phenylalanine Ammonia Lyase
PCAARRD	Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
PCR	Polymerase Chain Reaction
PDA	Potato Dextrose Agar
PDI	Percent Disease Incidence
PDS	Percent Disease Severity
PGPM	Plant Growth Promoting Microbes
PGPR	Plant Growth-Promoting Rhizobacteria
PGR	Plant Genetic Resources
PKVY	Paramparagat Krishi Vikas Yojana
POS	Production Oriented Survey
POX	Peroxidase
PPO	Polyphenol Oxidase
PPPs	Plant Protection Products
PR&D	participatory Research and Development
PSRB	Phosphate Solubilizing Rhizobacteria
PVY	*Potato virus Y*
qRT-PCR	Quantitative Real-time-Polymerase Chain Reaction
QTL	Quantitative Trait Locus
RA	Relative Abundance
RCA	Rolling Circle Amplification
RIL	Recombinant Inbred Line
RPA	Recombinase Polymerase Amplification
RT-PCR	Reverse-Transcription Polymerase Chain Reaction
SA	Salicylic Acid
SAARC	South Asian Association for Regional Cooperation
SALB	South American Leaf Blight
SALT	Sloping Agricultural Land Technology
SAPPDN	South Asia Plant Pests Diagnostic Network
SAUs	State Agricultural Universities
SDGs	Sustainable Development Goals
SEALNET	South-East Asia Laboratory Network
SEM	Scanning Electron Microscope
SKUAST	Sher-e-Kashmir University of Agricultural Sciences and Technology
SLCARP	Sri Lanka Council for Agricultural Research Policy

Acronyms and Abbreviations *(cont..)*

SLM	Sustainable Land Management
SMS	Spent Mushroom Substrate
SOC	Soil Organic Carbon
SOC map	Soil Organic Carbon mapping
SOD	Superoxide Dismutase
SOM	Soil Organic Carbon
SPC-LRD	Suva, Fiji-The Pacific Community – Land Resources Division
SRI	System of Rice Intensification
SSNM	Site and Soil Specific Nutrient Management
SSM	Sustainable Soil Management
SSU	Small Subunit
ST	Seed Treatment
SVVCP	Strengthening Vegetable Value Chain in Pakistan
TARI	Taiwan Agricultural Research Institute
Tef-1	Translation Elongation Factor 1-alpha
TEM	Transmission Electron Microscope
TMB	Tea Mosquito Bug
TYLCD	Tomato Yellow Leaf Curl Disease
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change.
URPs	Universal Rice Primers
UV-VIS	Ultra Violet- Visible Spectroscopy
VanMV	*Vanilla mosaic virus*
VCTAT	Value Chain Technical Assistance Team
VGSSM	Voluntary Guidelines for Sustainable Soil Management
VNV	Vanilla necrosis virus
VSDP	Volunteer Soil Doctors Program
WCM	Wheat Curl Mite
WSD	World Soil Day
WSMV	*Wheat streak mosaic virus*
WTO-SPS	World Trade Organization- Sanitary and Phytosanitary Agreement
AVRDC	World Vegetable Center
YEM	Yeast Extract Mannitol
YEPFA	Yeast Extract Potato Fructose Agar

Executive Summary

A '**Regional Conference on Role of Soil and Plant Health Towards Achieving Sustainable Development Goals in Asia-Pacific**' was held on November 21-23, 2018 at Rama Gardens Hotel, Bangkok, Thailand. The conference was organized by the Asia-Pacific Association for Agricultural Research Institutions (APAARI), Thailand in collaboration with Australian Centre for International Agricultural Research (ACIAR), Australia; Council of Agriculture (COA), Taiwan; International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India; Indian Phytopathological Society (IPS), India; International Rice Research Institute (IRRI), the Philippines and Department of Agriculture (DOA), Thailand. The objectives of the conference were i) to share the experiences on the soil and plant health, soil biodiversity, emerging crop pests and diseases through ecosystem approach in the context of climate change and ii) to suggest location- specific measures and provide a platform to identify regional priorities and also to catalyse the global initiatives through new collaborations, regional networks and projects and sustainable partnerships for knowledge sharing on experiences and best practices; and to explore innovative ways of investments to harness the potential of agricultural productivity towards achieving Sustainable Development Goals (SDGs) in the Asia-Pacific Region (APR). Accordingly, member country representatives, global experts and other stakeholders were invited. In all, 161 participants from 18 countries (Bangladesh, Bhutan, Nepal, Fiji, India, Iran, Italy, Lao PDR, Malaysia, Japan, Papua New Guinea, the Philippines, Samoa, Sri Lanka, Taiwan, Thailand, USA and Vietnam) participated in the meeting. The participants comprised of policy makers, Food and Agriculture Organisation (FAO) experts, researchers from National Agricultural Research Systems (NARS), Consultative Group on International Agriculture Research (CGIAR) Centers and other international experts, donors, private sector and Civil Society Organziations.

The conference was structured to include an inaugural, 10 technical and plenary sessions. The technical sessions comprised (i) Regional Initiatives and Priorities of Soil Health for Research and Development (7 & 6 speakers from South and West Asia & South East Asia and Pacific, respectively); (ii) Climate Change, Sustainability and Value Chain (10 speakers); (iii) Regional Initiatives and Priorities of Plant Health for Research and Development (6 & 9 speakers from South Asia & South East Asia and Pacific, countries, respectively); (ivA) Knowledge Management, Outreach and Commercialization (3 speakers) (ivB) Poster Presentations (31); (v) Eco- friendly approaches for Soil and Plant Health Management (10 speakers); (vi) Quarantine, Diagnosis, Taxonomy and Biodiversity (12 speakers); (vii) Plant Health Management- Case Studies (14 speakers); (viii) Plant Health Management – Research Trends (14 speakers) and (ix) Panel Discussion: Policy and Capacity Development on Soil and Plant Health (12 speakers), The deliberations held during the conference brought forth many important issues that need immediate attention, and participants gave several suggestions and recommendations. It was unanimously agreed that the technologies evolved in management of soil and plant health have tremendous potential to contribute significantly towards achieving the sustainable development goals (SDGs) on ending hunger, poverty alleviation, good health and well-being, besides attaining sustainable production and consumption, climate change and sustainable use of ecosystems. Recommendations that emerged from the regional conference under different heads are briefed below.

Priority Research Areas for Soil Health

- Restoration of soil health adopting soil health management measures to cope with climate change in sustainable way.
- Soil pollution research with focus on polluting chemical residue including crop residues burning and deposition of by-products, fossil fuel combustion and effective mining.
- Safe pesticide/ fertilizer management, scavenge heavy metals and arsenic exploring nanotechnology and nano-biotechnology and crop management strategies for the reduction of greenhouse gas (GHG) emissions from agricultural lands.
- Strengthen research on soil microbial diversity and soil structure and carbon sequestered in the soil in comparison to forest ecosystems.
- C-sequestration as adaptation and mitigation strategy to climate change and use of microbial consortia cultures, vermicomposting, etc. for improving soil microbial health.

- New bio-fertilizers know-how, monitoring by remote sensor set on Unmanned Aerial Vehicle (drone) and use of Artificial Intelligence need to be given attention for restoration of soil health for sustainable agriculture in APR.

Priority Research Areas for Plant Health

- Enhanced research on plant growth-promoting rhizobacteria, bio-control agents, endophytes, arbuscular mycorrhizal fungiwith characterization, conservation and efficient delivery mechanisms.
- Innovations in areas of bio-pesticides and integrated pest management and bio-prospecting.
- Combining of biological and chemical pesticides in consortia and facilitating trade with acceptable residue levels and Decision Support systems.
- Regional collaborations for disease resistance breeding in crops.
- The response of pests and diseases to climate variation and extreme events.
- Validation of traditional plant health management practices; scientific assessment of prioritized crop losses in the region; addressing the problems of new and emerging pests, diagnostics for races/ pathotypes, early warning systems and pest-risk analysis.
- Phytosanitary treatments of alternatives to methyl bromide, research on safe trans-boundary movement of bulk consignments.
- Bio-security needs of the region and integrating research on soil, water and nutrient effects on plant health

Capacity Development

- Enhancing the scientific capacities in the field of microbial technology for sustainable soil health.
- Farmers empowerment through capacity building and customization of technological packages.
- Integrating Farmer Field Schools with focus on agronomic and ecological factors.
- Building capacity of smallholder farmers on the practice of sustainable soil management (SSM) and integrated pest management.
- Encouraging Good Agricultural Practices and integrated communication technologies in soil resource and plant health care management.
- Establishing good linkages between education and extension for accurate soil data, information.
- Introducing the importance of soil resource and its care and vis a vis plant health care in the text books at schools and extending it to more professional levels.
- MOOCs and other ICT modules to be developed in regional languages; Create partnerships for knowledge dissemination; Creation of New Knowledge Management APAARI Platform.
- Village level soil health CoE of soil management research and human resource development.
- Regional capacity building in the field of bio-security and bio-safety.

Technical Infrastructure Development

- Establish soil health, soil testing laboratories, especially at local level.
- Centralized infrastructure for soil & water analysis, plant tissue testing with new tools and techniques.
- Up-gradation of selected labs with strong monitoring mechanism with a public-private partnership.
- Plant health clinic and disease diagnosis laboratories should facilitate issuance of sanitary & phytosanitary certificate for export and trade of agricultural commodities.
- Technology business incubators which act as innovation centres to be developed.
- Investment in research needs to be linked with national agriculture plan,which will require soil and plant health plans and clear business models.
- Demand-driven support for infrastructure development is required.
- Bionexus may be created wherein institutes allow use of their facilities by any agency for sharing purposes through collaborations.
- Mechanisms for investment in research product development and marketing emerged for developing agri-inputs improving soil and plant health, including PPP model need to be developed.

Public Awareness

- Increasing public awareness on soil and plant health socio-economic aspects, and approaching demand-driven water management.
- Public communication/education with budgetary provisions is essential to create awareness about ill effects of soil pollution on environmental quality and food safety.
- Farmers should be trained to use Good Agricultural Practices in crop production through demonstrations and farm certifications to overcome harmful effect of chemicals.
- Farmers should be trained and empowered for mass production and use of bio-fertilizers, biopesticides, bioagents for sustainable and eco-friendly management of pests.
- Farming community to be made aware of soil erosion, soil degradation and benefits of soil health improvement through action learning tools.
- Educate the farmers on harmful effects of injudicious use of chemical pesticides which effects negatively to people health as well as export of the agricultural commodities.
- Facilitate awareness on policies and educate on soil contamination with heavy metals, technology usage for better soil and plant health.

Policy Advocacy

- Strengthen national soil information systems for solid monitoring capacities of soil conditions.
- Plant quarantine legislation and amendment on regular basis be updated and documented for strict compliance.
- Upscaling of biocontrol agents and bio-pesticides and modifying as per local needs including capsule technologies involving youth as entrepreneurs.
- Review guidelines particularly for bio-agents registration, commercialization of microbial technology.
- Sharing of innovations and success stories which helps in agricultural productivity enhancement and upscaling of prioritized technologies.
- Regional cooperation for pre-export inspection of commodities for objectionable pest be strengthened by enacting law.
- Law for manufacturing and selling of spurious pesticides should be strengthened and enacted strictly as punishable offence.
- International financial institutions should be encouraged by policy advocacy for improved investments on soil and plant health.

Possible Partnerships

- Promote technical and scientific cooperation among countries for improving soil testing procedures, and to link to the Centre of Excellence for Soil Research in Asia (CESRA), the Global Soil Information System (GLOSIS), proposed Asian Soil Information System (ASIS), the Global Soil Laboratory Network (GLOSOLAN) and the Regional Soil Laboratory Network for Asia (SEALNET) as foreseen in the Asian Soil Partnership (ASP) implementation plan.
- Develop Soil organic carbon (SOC) map, bring out technical publications like Soil Atlas of Asia, conservation agriculture (CA) practices to promote carbon sequestration, providing incentives and rewards to farmers maintaining high soil organic carbon and good soil health as a baseline for subsequent partnership and networking.
- Build partnerships and networking of groups and institutions to work on select key issues, deliverables and budget in soil and plant health for South-South Cooperation.
- Models of effective Public-Private Partnership (PPP) may be adopted for small and marginal farmers focusing on advanced technologies at affordable costs.
- Partnerships should be promoted to use latest tools of biotechnology for enhancing conservation and capacities of bio-resources for sustainable use.
- Mechanisms to facilitate sharing of experiences and lessons learn on PPP,commercialization of microbial biotechnology of soil and plant health and innovations including licensing, Intellectual Property Rights issues and royalties.

- Partnerships should be promoted to use latest tools of biotechnology for enhancing conservation and capacities of bio-resources for their sustainable use and implementation of activities of International Network of Soil Information.

APAARI Action Points

Facilitate creation of Regional Soil and Plant Health Knowledge Platform with FAO/ other international bodies for taking up the following activities:

- Bring awareness on the issue of crop residue management technologies to avoid burning that causes soil and environmental pollution.
- Develop focused capacity building modules and policy briefs and facilitate collaborative projects on different aspects of soil and health management directed to all levels of stakeholders including policy makers.
- Facilitate workshops/meetings to promote partnerships/networks with the private sector and related to international funding opportunities for promoting soil and plant health.
- Facilitate studies on impact assessment of successful technologies on soil health and document the same to promote the use of those technologies that contribute to achieve SDGs in the APR.
- Facilitate regional linkages with the Centre of Excellence for Soil Research in Asia (CESRA).

Introduction

Deteriorating soil health, emerging pests and development of nutritional disorders and other factors causing ecological imbalances cannot be dealt with in isolation. Environmental concerns include the overuse of chemicals for pest management, climate change and poor soil conditions through natural causes or mismanagement. Soil health being an attribute of physical, chemical and biological processes is constantly declining and is often cited as one of the reasons for stagnating or declining crop yields and low input use efficiency. The physical, chemical and biological degradation of soil health along with inadequate and imbalanced nutrient use and neglect of organic manures is the cause of multi-nutrient deficiencies (secondary, macro and micro- nutrients). This coupled with poor field water management is the major cause of low crop productivity and reduced nutrient and water use efficiency. The biodiversity of the organisms in the soil perform vital ecosystem services that include nutrient cycling, aiding in soil formation and regulation of atmospheric composition and climate, improving water quantity and quality, as well as maintaining soil productivity.

In a recent study by the International Plant Protection Convention, it was found that the most important issues in Asia and the Pacific are the need for strengthened phytosanitary capacity, emerging insect pests and changing environment. Further, annual potential costs globally due to spread of pests and pathogens is estimated at USD 540 billion. Emerging pests in general and the environment are also important concerns for Asia-Pacific Region (APR). The main phytosanitary capacity needs of Asia are pest surveillance, inspection, pest reporting, diagnostics and use of phytosanitary treatments. Range of direct crop yield losses due to pests and diseases is between 20 and 40% without reflecting true costs to consumers, public health, societies, economic fabrics and farmers. More than twenty insect pests and several diseases contribute to these crop yield losses in addition to post-harvest losses. Studies on interaction of soil and plant health and their interdependence in the context of climate change are rather limited. More bio-diverse soil environments have more kinds of predators that reduce the chance of some species to dominate, which in turn reduces the risks of diseases in plants and humans, and control growth of pests. High soil biodiversity is also high in natural pest control potential, as it enables a higher probability of hosting a natural enemy of the pests. Pests serve ecosystems in regulating biodiversity itself. Soil-borne pathogens and herbivores control plant abundance, which enhances plant diversity. Agrochemical inputs adversely affect soils with high biodiversity. Most soil quality evaluation has been done in North America and Europe though soil degradation is more severe in the subtropics and tropics. Land degradation issues are further complicated by the chronic poverty, political and social instability, and high rates of weathering that occur throughout the APR.

The Regional Conference focused on soil and plant health vis-a-vis climate change, ecological pest management, input supplies for soil and plant health, the role of soil and plant health in the value chain and related policy issues. The aim was to contribute to strengthen the national and regional initiatives broadly on protecting soil and plant health. It will be a platform to share region specific long-term experiences on the neglect of soil and plant health, soil biodiversity, emerging insect pests and diseases through ecosystem approach in the context of climate change and variability; and suggest location-specific and region-specific measures and provide a plat- form to catalyze the global initiatives through new collaborations, regional networks and projects. Soil and plant health related issues being highly location, soil, plant/crop and management specific, the deliberations contributed to set the regional priorities on research, development, extension and policy in the Asia pacific involving various stakeholders. The importance of capacity development and relevant policy interventions was highlighted for achieving the targets.

Creating awareness amongst the stakeholders/masses on the significance of soil and plant health and the health of human and animals and its impact on the environment should form a part of knowledge management and knowledge sharing program.

In order to discuss and deliberate the role of soil and plant health towards achieving sustainable Development Goals (SDGs) in the APR, experts from Asia-Pacific Association of Agricultural Research Institutions (APAARI) member countries and other regional and global organizations, in the fields of soil and plant health and members of professional societies were invited to this Regional Conference (List of Participants- Annex I). The Regional Conference was conducted from 21-23 November 2018 in nine technical sessions (Technical Programme

- Annex II) in addition to the Opening and Plenary Sessions. Opening Session in addition to remarks from the dignitaries including the Chief Guest, two key note addresses were made one each on soil health and plant health. The technical sessions covered the regional initiatives and priorities for soil and plant health; climate change, sustainability and value chain; knowledge management, outreach and commercialisation; a poster session covering soil and plant health; eco-friendly approaches for soil and plant health management; quarantine, diagnosis, taxonomy and biodiversity; case studies on plant health management; research trends in plant health management and a panel discussion on policy and capacity development on soil and plant health. The plenary session consolidated recommendations of all sessions on soil and plant health and also discussed modalities for establishing a regional platform on soil and plant health. The gist of the presentations in each session and the recommendations that emerged based on discussions are presented below:

Inaugural Session

The conference began with a warm welcome of dignitaries and delegates by Ravi Khetarpal, Executive Secretary, Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand. While introducing the topic of Soil and Plant Health, being unique and also being addressed for the first time together, he highlighted the significant role the soil and plant health play in achieving the Sustainable development Goals (SDGs). He emphasized that deteriorating soil health, emerging pests and development of nutritional disorders and other factors causing ecological imbalances cannot be dealt in isolation. The environmental concerns include overuse of chemicals for pest management, climate change and poor soil conditions through natural causes or mismanagement. He informed that FAO has initiated a number of global and regional programs to ensure soil and plant health. Further, he said that soil and plant health-related issues being highly location-specific; hoped that the deliberations will contribute to set the regional priorities on research, development, extension and policy in the Asia-Pacific involving various stakeholders. The objective of this regional conference is to develop a regional knowledge platform to access new technologies within and outside the region to enhance soil and plant health. He placed on record his gratitude to all the sponsoring organizations and members of APAARI, for their help in organizing this regional conference. Brief remarks of the dignitaries are provided below:

Warawut Chootummatouch, DOA, Thailand stressed the importance of the regional conference as soil health plays an important role in enhancing productivity and sustainable development of farmers through the overall development in agriculture. It is important to adopt eco-friendly approaches to prevent crop losses to cope up with the challenges of climate change. The research for development in the APR should address the issues while ensuring the food security in the region. He highlighted the significance of soil organic carbon and carbon sequestration, soil ecology and regional collaboration in achieving the goal of sustainable development by 2030. Louise Whiting, FAO RAP, Thailand presented an overview of food insecurity and informed that approximately 33% of our global soils are degraded, leaving agriculture vulnerable and food security at risk. Policy makers around the world are exploring opportunities to embrace sustainable development via the SDGs. About 99% of the world's food supply comes ultimately from land-based production with about 50-70% of the land devoted to agriculture. Modern agricultural methods increased the reliance on external inputs to maintain productivity, which in the long run is unsustainable. Agriculture must, literally, return to its roots by rediscovering the importance of healthy soil, drawing on natural sources of plant nutrition, and using mineral fertiliser wisely. The unique role of soils in influencing the management and use of other resources such as water, land, nutrients and biodiversity validate the efforts of the scientific community towards integrated resource management. Agriculture, and consequently, soils are at the heart of the SDGs (SDG 1, 2, 3, 6, 13,15 and 17) and are fundamental towards achieving them. It has been agreed upon that cross-sector integrated work is imperative towards achieving the SDGs implying that soils also have an indirect presence in achieving the remaining goals.

The mandate of the Global Soil Partnership (GSP) is to improve governance of the limited soil resources of the planet in order to guarantee agriculturally productive soils for a food secure world, as well as support other essential ecosystem services, in accordance with the sovereign right of each State over its natural resources. To achieve its mandate, the GSP addresses five pillars of action to be implemented in collaboration with its regional soil partnerships. There is an urgent need to raise awareness on the importance of soil, especially the need to protect soils and use them sustainably. We are at a point, he said, where all the calls and pleas for action to mitigate the consequences of environmental degradation and climate change are just not sufficient anymore. It is time that we look over the fence towards other disciplines to reach out and form genuine collaborations. Despite advances in certain areas, more needs to be done to accelerate progress. All stakeholders will have to refocus and intensify their efforts on areas where progress has been slow. Yuxin Tong, FAO, Rome congratulated the organisers for conducting this conference and very briefly narrated the importance and relevance of this regional conference. Later he detailed the technical aspects in his keynote address. RN Pandey, President, Indian Phytopathological Society (IPS) welcomed the participants and highlighted the importance of plant pathology in diagnosis and management of plant diseases for robust plant health to achieve the optimum yield of the plants and sustainability of agriculture. He discussed the emerging threats of plant diseases in the wake of climate change and trans-boundary movement of the pests. He also introduced the IPS (http//www.ipsdis.org) which has completed 72 years in the service of plant pathology and is the 3rd largest society of the world.

The society has eight zonal chapters spread all over India and has also collaborations with 'The American Phytopathological Society, USA (https://www.aps.net) and Asian PGPR Society for Sustainable Agriculture (http://asianpgpr.com), USA. The society is organising annual and zonal conferences for the benefit of plant pathologists, students, farmers, corporate houses and other stakeholders. He offered the services of expert scientists available with the society for the benefit of member countries of APAARI. HE Chen-Yuan Tung, Representative TECO, Thailand wished the conference the best and congratulated APAARI for this initiative. **HE Luck Wajananawat, Deputy Minister of Agriculture and Cooperatives, Thailand** was the Chief Guest in the Inaugural Session. On this occasion, he released some of the publications brought out by the APAARI. In his inaugural address he highlighted the role of soil and plant health in achieving the SDGs. He lauded the efforts of APAARI to organise

a regional conference on such an important topic which is directly linked with hunger and the food security of the people. The world population is likely to be 11 billion by 2050 and we have to feed a large number of people against the threats of climate change. The only option is to increase the agricultural productivity. Soils are fundamental to increase the food production and productivity and hence their careful management is essential for sustainable agricultural production and empowerment of women. He emphasized that we need to give more attention for improving water availability. He said that realizing the significant role that soils play in food and environmental security and in abating climate change, the United Nations declared 2015 as the year of soils. Similar to this the International Union of Soil Science (IUSS) has declared 2015-2024 as the International Decade of Soils. Similarly, plant health, he said, is the key to the sustainable intensification of agriculture to feed the growing global population by 2050. Global efforts are being made to save colossal crop losses from the ravages of insect pests and diseases but the approach towards this endeavour has to be pragmatic and environmental concerns are to be kept in mind.

The FAO Conference in July 2017 approved a resolution requesting the General Assembly of the United Nations to consider declaring 2020 as the International Year of Plant Health. SDGs 1,2, 3, 13 and 17 can be addressed by ensuring sound plant health. FAO has initiated a number of global and regional programs to ensure soil and plant health. This has to catalyse the national programs and priorities in the region. He also referred to the World Soil Charter and emphasised that great understanding of soils is essential as the world over there is a threat to the ability of soils to produce on a sustainable basis. He further said that there is a need to obtain systematic information on soil and plant health, water quantity and quality on a regional basis and bring out a series of recommendations to achieve the SDGs. At the end he declared the conference open, wished good luck and hoped that deliberations will bring out valuable recommendations for the welfare of farmers of APR.

Keynote Addresses - Soil Health
Co-chair: Pearl B Sanchez, Siva Annamalai
Rapporteurs: CL Acharya, KS Varaprasad

Yuxin Tong, FAO, Rome delivered the keynote address on Sustainable Development Goals and Soil Health. Tong said that on 25 September 2015, the 193 Member States of the United Nations adopted the 17 SDGs of the 2030 Agenda for Sustainable Development. Global objectives are expected to guide the actions of the international community over the next 15 years (2016-2030) to end hunger, achieve food security, improved nutrition and promote sustainable agriculture. SDG 13 requires urgent action to combat climate change and its impacts while SDG 15 is about sustainable management of forests and SDG 8 is linked to soil health.

The Global Soil Partnership (2012), he said, promotes Sustainable Soil Management (SSM) to improve soil governance at all levels to support/enhance the provision of essential ecosystem service. He also referred to World Soil Day (WSD) which is held annually on 5 December and GLINKA World Soil prize as a means to focus attention on the importance of healthy soil and advocating for the sustainable management of soil resources. He further said that GSOP18 states “Be the Solution to Soil Pollution” to raise awareness on soil pollution threat to human health and the environment. Volunteer Soil Doctors programme from Thailand, is to build the capacity of small-holder farmers on the practice of SSM to support governmental agencies.

Other objectives being to enhance the quantity and quality of soil data and information and set the basis for establishing and/or reinforcing national soil monitoring activities; to support field research; and to promote technical and scientific cooperation among countries for improving their soil testing procedures. Further, he said, that there is a move for implementation of the Global Soil Doctors programme in Asia. The GSP will work with the Government of those countries willing to implement the programme at the national level for developing country-tailored implementation strategies. The programme, he said, will be launched on 5 December 2018. He also informed about Global Symposium on Soil Organic Carbon (GSOC17) aimed to gather scientific evidence for policy development on the role of Soil Organic Carbon (SOC) for climate change, food security and SDGs agendas. Further, he informed that the International Symposium on Black Soils & First Plenary of International Network of Black Soils (INBS18) finalised its working plan. Special emphasis is being given on soil pollution which is threatening the achievements of 12 of the 17 goals for sustainable development. He also informed that the First Session Workshop of International Network of Soil Information Institutions (INSII) including the Global Soil Information System (GLOSIS) was held.

He appealed to contribute to bring out Technical publications like Soil Atlas of Asia and to link to the Center of Excellence for Soil Research in Asia (CESRA) as foreseen in the ASP implementation plan. The GLOSIS envisages the establishment of the Asian Soil Information System (ASIS), The Global Soil Laboratory Network (GLOSOLAN) and the Regional Soil Laboratory Network for Asia (SEALNET). Tong also outlined the Work Plan 2019/2021 as implementation of the recommendations of the Global Symposium on Soil Organic Carbon as connected to the Koronivia Joint Work of the COP23- UNFCCC and Paris Agreement; Organization of the Symposiums on Soil Erosion in 2019, Soil Biodiversity in 2020 and Soil Nutrient Management in 2021; Enhancing the soil biodiversity work through the Global Assessment of Soil Biodiversity; Establishment of the GLOSIS including the Monitoring System of the GSOC map; Implementation of Activities of the Intergovernmental Technical Panel on Soils (ITPS), including the collaboration with IPCC and United Nations Convention to Combat Desertification (UNCCD); Execution of Regional Implementation Plans (field activities); Implementation of Activities of International Network of Soil Information Institutions (INSII), International Network

of Black Soils (INBS), GLOSOLAN and Soil Doctors Programme.

Pitayakon Limtong, GSP/ASP National Focal Point, Thailand presented the keynote address on 'Overview of Global and Asian Soil Partnership (ASP)'. He informed that the status of soil erosion, organic carbon change, salinisation and sodification, nutrient imbalance, contamination, soil sealing and land take, soil acidification, compaction is all rated to be poor and in deteriorating category while water logging and loss of soil biodiversity falls in the fair category. Loss of organic carbon change, salinisation and sodification and loss of biodiversity are variable. He said that healthy soils have good physical, chemical and biological attributes and all efforts should be made to conserve the soil resources. He enlisted Soil Information System; Conservation, Restoration; Soil Research, Extension; Soil Management; Soil Institutions; Awareness Raising; Education and Policy as steps towards this effort of maintaining healthy soils. He also referred to GSP, 2012 as a mechanism to develop a strong interactive partnership and enhanced collaboration and synergy of efforts among the stakeholders. From land users through to policy makers, he said, one of the key objectives of the GSP is to improve the governance and promote sustainable management of soils. The World Soil Day campaign aims to connect people with soils and raise awareness. The Regional Soil Partnerships include North America, Central America, South America, Europe, Near East and North Africa, Africa, Asia, and Pacific. The ASP 2012 consists of 24 countries that include Afghanistan, Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam. The key priorities of the ASP are to: facilitate interactive processes involving a range of entities and stakeholders; interact with regional soil science societies and other mechanisms; discuss and provide guidance on regional goals and priorities as regards soil science on important issues mechanisms and catalyse cooperation within the region. In ASP 2015, the World Soil charter and Status of the World's Soil Resources were presented. In ASP 2016 the Asian Implementation Plan (for five years) and Awareness Raising, Research, Soil Management, Harmonisation and Information & Data were highlighted. The ASP has five Pillars being, Pillar 1: Promote sustainable management of soil resources for soil protection, conservation and sustainable productivity, Pillar 2: Encourage investment, technical cooperation, policy, education, awareness and extension in soil, Pillar 3: Promote targeted soil re- search and development focusing on identified gaps, priorities and synergies with related productive, environmental and social development actions, Pillar 4: Information and Data, and Pillar 5: Harmonization of methods, measurements and indicator for the sustainable management and protection of soil resources. He further elaborated ASP 2017 and ASP 2018; ASP 2017: SOC Map- ping, South-East Asia Laboratory Network (SEALNET); ASP 2018: Volunteer Soil Doctors program (VSDP) and Center of Excellence for Soil Research in Asia (CESRA). The five major activities for execution in the ASP Implementation Plan are: Pillar1: the Voluntary Guidelines for Sustainable Soil Management (VGSSM) – 2018, Pillar2: VSDP- 2018, Pillar3: the CESRA- 2018, Pillar4: the national SOC map- 2017, and Pillar5: the SEALNET- 2017.

Ravi Khetarpal, APAARI, Bangkok presented a keynote address on the 'Plant Health Scenario and Sustainable Development Goals in Asia Pacific'. He presented importance of plant health in relation to SDGs, issues in Asia-Pacific, regional efforts needed to achieve SDGs, recent initia- tives by APAARI and the need for enhanced co-ordinated efforts. He expressed that the SDGs 1, 2, 3, 5, 12, 13 and 17 are related to the theme of the conference directly or indirectly, therefore, the soil and plant health is very important for achieving sustainable goals particularly in the countries of Asia-Pacific. He emphasised the importance of plant health by quoting that for every 1% of crop losses saved we can feed 25 million hungry people. Therefore, the 'Second Committee of the UN General Assembly adopted a resolution by consensus that the year 2020 is celebrated as the 'International Year of Plant Health 2020'. He presented the regional scenario of plant health as challenges and opportunities i.e. wide variations in climate with high degree of plant diversity, destruction caused by various pest species, overuse of pesticides, soil health vis a vis plant health often neglected, international trade leading to introduction of invasive alien pests causing billions of dollars losses. He cited a few well known pests of Asia Pacific as *Schistocera gregaria* - the fastest flying transboundary plant pest, the desert locust; *Bactrocera zonata*-the peach fruit fly infesting over 50 species of fruits and vegetables; Brown Plant Hopper (BPH)- a major pest of rice for which Asia is the global rice bowl; Wheat yellow rusts- a perpetual threat for wheat in Asia and Pacific and UG99- a virulent strain of stem rust, a recent threat for wheat in Central and South Asia. He discussed about distribution of some emerging pests in Asia- Pacific and also limited distribution of some important pests in Asia-Pacific viz. *Banana bunchy top virus* (BBTV), wheat blast, pine wood nematode, western flower thrips, apple fire blight, coffee berry borer, tomato leaf miner, etc. He cautioned that some important pests not yet reported from Asia pacific viz. South American leaf blight of rubber (*Microcyclus ulei*), South American fruit fly (*Anastrepha fraterculus*), Mexican cotton boll weevil (*Anthonomus grandis*), Ergot of maize , (*Claviceps gigantea*), Rice yellow mottle virus and Maize streak virus are thepotential threat to these countries.

He drew the attention of the 'Most Recent Issue on Plant Health' i.e. the Fall Armyworm (FAW) which is a major threat to food security as it spreads quickly. It cannot be eliminated once it has invaded a country. It has also recently been detected in Yemen and India. The estimated value of loss of crops due to FAW is USD 2400 to 4800 million per year. FAO launches a mobile application to support fight against FAW in Africa. He presented the global instruments of plant health such as International Plant Protection Convention (IPPC) dealing with plant protection, World Trade Organization- Sanitary and Phytosanitary (WTO- SPS) Agreement dealing with trade, Convention on Biological Diversity (CBD) for protecting biological diversity and for fair and equitable sharing of benefits arising from the use of genetic resources; Cartegena Protocol on Biosafety (CPB) for protecting biological diversity from Living Modified Organisms (LMOs). He presented 'Role of FAO Regional Cooperation and Coordination' in which he suggested the need for FAO's Emergency Prevention System for Transboundary Ani- mal and Plant Pests and Diseases (EMPRES) to provide support to governments in areas of transboundary movement of pests. The Asia and Pacific Plant Protection Commission (APPPC) with its headquarters at Bangkok, coordinates and promotes the development of regional plant protection systems; assist member countries to develop effective plant protection regime and facilitates information sharing.

He also presented APAARI's 'Vision 2030' giving priority for Strengthening Agri-food research and innovations for sustainable agricultural development in the APR. He gave ‘Strategy Plan 2017-22 with four key thematic areas viz. ‘Natural resource management’, ‘Risk mitigation’, ‘Inclusive development’ and ‘Policy and advocacy’. Also he presented the initiative taken by APAARI as ‘Knowledge management’ by Establishment of Knowledge Hub for SPS Capacity Development for Asia Pacific; ‘R & D for enhancing trade and environment protection’ by Asia Pesticide Residue Monitoring and Promotion of Bio-pesticides for Trade; ‘Capacity building’ in the area of Integrated Pest Management (IPM) Training for South Asia in partnership with South Asian Association for Regional Cooperation (SAARC)’; Co-ordination (expected) by ‘Establishment of a Regional Platform for Plant and Soil Health Management after Brain storming in a Regional Conference. He expressed his concern regarding injudicious use of the pesticides and therefore planned for ‘Asia Pesticide Residue Mitigation through the Promotion of Bio-pesticides’. For achieving the same he has proposed the program ‘To develop a framework in synergy with FAO’s IPM work in Asia’, ‘To combine bio-pesticides with the use of conventional pesticides to reduce chemical residues’. This is expected to reduce trade issues linked to

pesticides in tropical fruits and vegetables, reduce exposure of consumers to pesticide residues and of farmers to higher-risk synthetic pesticides, and have wider environmental benefits. In this regards APAARI is to work with Lao PDR, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand, Viet Nam, CropLife Asia, and Rutgers University, USA. At the end he highlighted ‘Six Key Issues in Asia-Pacific’ including ‘losses and economics yet not documented rationally, package of practices like IPM is too heavy to be adopted’, use of audio visual aids, media, apps with not enough field orientation, ‘non-availability of local pest database which makes pest risk analysis for export difficult, ‘Backward linkages missing and ‘non- documentation of impact of outputs beyond publications. At the end he emphasised the ‘need to look at plant and soil health in an integrated manner and need for a Regional Platform for knowledge sharing.

Technical Session I
Regional Initiatives and Priorities of Soil Health for Research and Development
Co-chairs: Yuxin Tong, Girish Chander
Rapporteur: Margaret Yoovatana

The first session consisted of presentations from six countries of South and West Asia and eight countries of South East Asia and Pacific regions.

Bangladesh country report was presented by Nirmal Chandra Shil, Bangladesh Agricultural Research

Institute (BARI), Bangladesh. The food requirement of Bangladesh will be double than the present production by 2030, its soil resource is shrinking by 0.73% per year due to the use of agricultural land into non-agricultural purposes. The major reasons for the depletion of soil fertility in Bangladesh are increased intensity of cropping with high yielding varieties, imbalanced fertilisation, deficiencies of secondary and micronutrients, gradual decrease in soil organic matter and soil degradation due to erosion, acidification, salinisation, alkalisation, pollution, compaction, etc. In such situation, role of soil science assumes significance to manage soils towards sustainable growth in agriculture harmonising economic, social and environmental imperatives. He highlighted the soil related major constraints as depletion of soil fertility, soil erosion, raising of soil acidity, intrusion of soil salinity, low soil moisture content due to drought, submergence and water logging, intensity of zinc and boron deficiencies, phosphate fixation, plough pan and soil compaction, leaching of nitrogen and basic cations, low organic matter content and soil and water pollution.

Crop residues instead of incorporation are taken away depriving soil, cow dung burnt, excessive puddling causes plough pan formation, silt and sand removed from crop land, fertile soil used for brick making, shifting cultivation in hill tracts, water pollution due to textile and tannery industries ultimately cause degradation of soil health. He laid emphasis on improving physical, chemical and biological aspects of soil health, bringing of problem soils (char land, waterlogged soils and soils with hard pan etc.) under successful crop cultivation, organic farming for safe food production, location-specific fertiliser management, identification of pesticide and heavy metal decomposing/fixing micro organisms, collection, isolation, identification of soil microorganism capable to act as a pest and disease controlling agents for the development of bio- pesticides, use of nanotechnology and nanobiotechnology for higher fertiliser use efficiency and to scavenge heavy metals and arsenic from soil-water-plant system, fertiliser and crop management strategies for the reduction of green house gas emissions from agricultural lands. He also spoke on the need for regional cooperation and partnership; sharing and exchange of knowledge, experience and expertise; strengthening of laboratory and capacity building; coordinated research in solving regional problems on soil health and climate change issues; creation of regional soil health village as a centre of excellence of soil management research, and human resource development.

Bhutan country report was presented by Tashi Uden, National Soil Services Centre, Bhutan on the Soil and Plant Health in Bhutan. She said that Bhutan is a mountainous country prone to land degradation leading to low soil fertility. This problem is further aggravated with inadequate nutrient inputs (imbalance nutrient inputs) and intensive cropping leading to excessive nutrient mining. There is no concrete policy on soil fertility improvement in the country and facilities for soil and plant analysis are also inadequate. Rapid urbanisation is causing more waste of land leading to more soil pollution. From 1998 to 2015, she said, a total of 306.56 ha of wetland were lost for urbanisation. The major challenges are limited arable land which necessitates continuous cropping, resource constraints, especially, human capacity, farm labor and funds to sustain free soil and plant analysis and recommendations thereof, lack of fertiliser recommendation guideline suitable for various agroecological conditions and soil types. The recent initiatives taken are observing world soil day and land management campaign (June 17th), promoting IPNM to improve soil health and crop yields, training communities on sustainable soil fertility management/ IPNM, promotion of organic fertilisers and farm yard manure to improve soil health and production of healthy food. The priority areas are organic agriculture and promotion of organic fertilisers and green manure crops, land terracing to prevent soil erosion and improve fertility, farm mechanisation to improve farm productivity, construction of new and maintenance of old irrigation canals and promotion of rain water harvesting technologies.

India country report was presented by SK Chaudhari, Indian Council of Agricultural Research (ICAR), India. who made a presentation on Soil Health Management: Indian Perspective. He said that out of 141 m.ha of land under cultivation 104.2 m.ha are degraded lands with annual soil loss of 5.3 billion tonnes carrying 8 m tonnes of plant nutrients, average soil loss is 16.4 t/ha.

Soils with physical constraints are 89.5 m.ha. There are heavy crop production losses through water erosion (13.4 mt), salinity (5.66 mt), alkalinity (11.18 mt), and wind erosion (6.85 mt). The soils have low soil organic carbon (< 0.5 %) and suffer from multi nutrient deficiencies, low nutrient use efficiency, a decline in fertiliser response ratio, imbalance fertiliser use and crop residue burning. The major concerns are monitoring land degradation for the conservation of soil resources, improving soil physical, chemical and biological health, managing crop residues, soil carbon sequestration to reduce carbon footprint and global warming, improving nutrient use efficiencies and fertiliser response ratio and reduce soil contamination.

Challenges of soil health in India are inadequate soil testing laboratories (1268 static + 368 mobiles) with aggregate analys- ing capacity of 15 million samples per annum. Fertiliser quality control laboratories are 82, farm science centers (KVK) 700 with portable soil testing kits, fertiliser plants 172 and bio-fertiliser production units 400 with a production capacity of 100,000 tons per annum. There are four soil research institutions, four All India Coordinated Research Projects, two Network Projects, and one Consortia Research Project. The Policy Initiatives taken are Coating urea with Neem (*Azadirachta indica*) oil, Integrated Watershed Management Program, National Mission for Sustainable Agriculture, National Mission on Soil Health Card, Paramparagat Krishi Vikas Yojana (PKVY)- A scheme on organic farming, National Biogas and Manure Management Program and provision of providing Nutrient Based Subsidy (NBS) to the farmers.

Nepal country report was presented by **Krishna Bahadur Thapa, Nepal Agricultural Research Council (NARC), Nepal**, who gave presentation on the 'Soil Health Issues and Challenges in Nepal. He said that Soil fertility in Nepal is largely maintained by the application of compost and farm yard manure, but in recent years a decline in soil fertility has been reported due to increasing crop intensification, decreasing livestock numbers, increasing use of chemical fertilisers, reduced labor availability and change in the climate and has shown decline in soil productivity over the last 30-40 years. The key issues are soil acidity, soil erosion/land degradation, poor organic matter, NPK and micronutrients, soil pollution with agrochemicals, reduced water holding capacity of soils, decrease in number of the beneficial organisms and increase of harmful organisms, low soil fertility and climate change. The challenges for capacity development are limited human and capital resources, infrastructure for research (laboratory buildings and equipment). On the extension side, there are good linkages between Education, Research and Extension with NAP 2004 and National Land Use Policy 2013. Recent initiatives in soil health management by different agencies being i) by farmer: Soil fertility management through agricultural practices such as green manuring, use of bio-fertilisers, integrated nutrient management (INM) techniques adoption of agro-forestry with NF trees species and other soil conserving techniques, ii) by Extension agents: promotion of technologies related to sustainable soil management such as training on improved composting technology, vermi-compost, agro-forestry and trainings related to INM, and iii) by Researchers: Research focused on increasing soil fertility, organic matter, bio- fertiliser and reclamation of polluted soils and techniques for soil conservation.

Sri Lanka country report was presented by **H Asiri S Weerasinghe, Sri Lanka Council for Agricultural Research Policy (SLCARP), Sri Lanka**, who made a presentation on 'Sri Lankan Soil Health: Issues, Challenges, Initiatives and Priority Areas'. He presented that 46 % of the land is arable land, with rainfall varying from < 1750 mm in the dry zone to 2500 mm in the wet zone with agriculture contributing 7.7 % to GDP of the country. Dominant soil orders being Alfisols, Ultisols and Entisols, encounter the physical problems like landslides which damage the soil structure. Soil erosion causes changes in soil texture and moisture whereas the use of heavy machinery during land preparation and harvesting causes soil compaction. The chemical problems faced are build up of P, K and chemical residues in soil, changes in soil pH, low cation exchange capacity (CEC) and organic carbon (OC) in soil and accumulation of heavy metals. The biological problems are low diversity and density of micro and macro organisms due to low OC in soil, excess fertiliser and pesticide use. The nematode population has increased in the wet zone affecting tea, rice and vegetables. There is also the problem of increasing coastal salinity and acidification, and desertification in the dry zones. Site-specific fertiliser recommendations and integrated plant nutrition systems to provide balance fertiliser with both inorganic and organic sources are being encouraged. For capacity-building, the knowledge, human resource and infrastructure are adequate but the policy implementation part is poor. Policy level encouragement for the usage of organic fertiliser is required. Priority areas to be addressed are improving / maintaining soil quality in dry and wet zones of the country under changing climatic conditions, addressing salinity problems of inland dry zones and of those close to the coastal areas, rehabilitation of marginal lands, and quantification of accumulated chemical residues (nutrients and heavy metals) in soil and its impact on plants and environment. **Iran** country report was presented by **Karim Shahbazi, Agricultural Research, Education and Extension Organization, Iran**, who made a presentation on 'Issues, Challenges and Priorities of Soil Health in Iran'. He elaborated that the soil health related issues are low organic carbon content (SOC in > 60% of soils is <1%), low plant-available nutrients (available P, Zn and

Fe in 70, 56 and 40 percent of soils are below the critical levels, respectively) and require annual fertiliser application to avoid profit loss, and soil contamination (with heavy metals and chemical com- pounds in site-specific due to disposal of municipal wastes and industrial effluents in areas around mines, industry, big cities).The reasons being, harsh climatic conditions, undeveloped soils and adoption of improper soil and crop management practices by the farmers. Out of the total of 8 m ha of irrigated land 6.8 m ha are affected by salinity. The salinity of soils and ground waters have been increasing in recent years due to poor water management, decrease of precipitations and overdraft of ground-water. The negative balance of recharge has resulted in both the lowering of ground water tables and higher salinity of irrigation water. Further, nutrient depletion in soils, deterioration of soil's physical properties (soil compaction, low soil water retention and low hydraulic conductivity), agricultural intensification and occurrence of dust storms are the other soil health-related issues.

The soil health challenges are soil, water and wastewater mismanagement, climate change, low public awareness, sectarian and disciplinary approaches in policy making and land use change. Recent achievements and initiatives taken by the Iranian government regarding soil health are passing the "Soil Conservation Law" in the parliament: (Iranian parliament passed "Soil Conservation Law" in September 2018), development of "Comprehensive soil fertility and plant nutrition program 2014-2025", establishment of the Office of Registration and Quality Control of Fertilisers, development of the National Soil Standards, development of "Research Program on sustainable soil and water management", 2015, starting soil quality monitoring project in agricultural lands since 2015, extension and educational activities, and development of comprehensive information databases. Priorities on soil health includes, development of sustainable soil management expert systems, preparation of soil organic carbon map, implementing conservation agriculture, reduction of soil erosion through improved watershed management, identification of polluted soils (location, type and degree of pollution), use of bio and organic fertiliser in agricultural land, conducting research on new bio-fertilisers know-how, increase of public awareness on soil's socio-economic aspects, and approaching demand driven water management.

Japan country report was presented by **Naruo Matsumoto, Japan International Research Center for Agricultural Sciences (JIRCAS), Japan** who spoke on the 'Regional Initiatives and Priorities of Soil Health for Research and Development in Japan'. He mentioned about Soil Fertility Enhancement Act (1984) and the Law for Promoting the Introduction of Sustainable Agricultural Production Practices (1999) in Japan. He referred to determining optimum application rate based on field experiments for soil and crop/ variety with the combined use of chemical fertiliser, manure and soil amendment. Under rice-upland crop rotation soil fertility decreased but no-tillage favored maintaining good soil fertility conditions. He also referred about the recovery of agricultural land after tsunami by the removal of debris and salt. This way the manure application rate decreased (from recommended dose of 10 t/ha) but Soil organic carbon content showed a reduction. Further, he showed that in 83% of paddy lands the K level is satisfactory but Mg is insufficient in 67% of paddy lands. However, Ca is excessive in 65% of paddy lands. He also spoke about on-going experiments on environmental conservation agriculture (since 1992) and mentioned that soil fertility improvement using manure, crop residues and other resources is resulting in reduced fertiliser application, reduction in input of agricultural chemicals which is contributing to the mitigation of climate change and biodiversity conservation. He also mentioned about balance of organic matter resource supply and manure application demand, dynamics of organic matter in soil particle, functionality of organic matter in soil for product quality and pest prevention, genome analysis of soil microorganisms, smart agriculture, precision agriculture, monitoring soil condition (nutrients, water) by remote sensor set on UAV (drone) and tractor combined with satellite data, ICT, meta data analysis and Artificial Intelligence (AI).

Taiwan country report was presented by Yu-Wen Lin, Taiwan Agricultural Research Institute (TARI), Taiwan, who made a presentation on the 'Experiences of Research and Development of Technologies on Soil and Plant Health Management in Taiwan'. He mentioned that excessive use of fertiliser is resulting in development of soil acidity, salinity, nutrient unbalance and water pollution. The soil is getting contaminated by heavy metals from municipal solid waste from in- creased urbanization, effluents from industrial growth and pesticide residues. The occurrence of drought, flooding, storm, abnormal temperatures has become a regular feature. It is becoming difficult to strike a balance between profitability and environment quality/food safety. There are conflicts between soil regulation and food regulation. Public communication / education on these aspects is essential with additional budgetary provisions. The results of soil survey and characterization of physical, chemical and biological properties undertaken by Taiwan Agricultural Research Institute, Department of Agricultural Research and Education indicated that there is more need for training on soil testing, laying of demonstrations, promotion and extension education.

The technological interventions like the use of microbial agents such as *Rhizobium*, Arbuscular Mycorrhizal Fungi (AMF), *Bacillus, Trichoderma*, etc. showed reduced fertiliser consumption since 2008 with registered organic fertilisers of 1371, registered bio-fertilisers as 34 and registered bio-pesticides as 37. The strategies to be adopted for food safety are raising soil pH, adoption of suitable varieties, restricting planting in vulnerable areas, efficient water management, strengthening research and extension activities, integrated pest management through monitoring population dynamics, developing environmentally friendly control materials, rational and safe pesticide management, adapting measures to cope with climate change such as under-facility cultivation, enhancing water use efficiency, managing the emerging pests/ diseases, suitable cropping system, developing decision support systems for prediction and adaption, and breeding of resistant varieties.

Lao PDR country report was presented by Singlty Voradeth, National Agriculture and Forestry Research Institute (NAFRI), Lao PDR. He presented on the 'Role of Soil and Plant Health towards Achieving Sustainable Development Goals in Asia-Pacific'. He highlighted that the major production comes from wet season rice cultivation which encounters the problem of iron toxicity that results in yield loss because of reduced growth, especially height, and reduced number of tillers. In these areas the soil organic carbon is low. Another acute soil problem is of soil salinity that negatively affects the rice yields as in other countries, especially in Sayyaboury, Vientiane province and Savannakhet province where from the main production comes. The other problems in rice production are that of insect pests and diseases. Specific variety recommendations for potential problem areas with special target characters such as low temperature, flood prone, drought prone, salinity, Fe toxicity, low soil fertility etc. have been made which are helping farmers to suitably obtain satisfactory yields in rice.

Malaysia country report was presented by Theeba Manickam, Malaysian Agricultural Research and Development Institute (MARDI), Malaysia, who made the presentation on the 'National Priorities for Sustainable Soil Health and Nutrient Management in Malaysia'. She informed that in environmental sensitive areas (highlands) the excessive cutting of slope for agricultural production is causing severe erosion resulting in sedimentation and siltation of lakes. These highlands are the main temperate vegetables and cut flowers production areas in Malaysia. The continuous use of chemical inputs is resulting in degradation of soil structure, development of soil salinity and a decline in soil fertility. The intensive farming practices to achieve high crop yields with the application of fertilisers at blanket rates specially for rice without altering soil pH are causing high accumulation of chemicals in soil and decline in soil microbial population. Further, heavy mechanisation on flooded rice system disturbs the hard pan layer and is causing soft soil problem. The agricultural production in acid sulphate soils that are over drained is affected by high acidity, Al and Fe toxicity. The sandy soils that have high drainage show the problems of fertiliser leaching low soil pH and low cation exchange capacity (CEC). Inefficient management is causing further soil degradation, chemical pollution and low crop yield production. The climatic factors like heavy rainfall cause floods, severe erosion and siltation that destroy infrastructure and affect crop production. Similarly, the prolonged drought is causing decline in soil living organism and microbial population which destroys soil structure and upsets the crop production. National priorities and strategies for sustainable soil health and crop nutrient management have been fixed through Malaysia Organic (Myorganic) and Malaysia Good Agricultural Practices (MyGAP) certification Schemes for transformation to the living soil. This is being done through zero chemical inputs, an increase in organic matter, carbon and soil ecosystem sustainability. Bio-fertiliser input is a part of government fertiliser subsidy scheme for rice production to reju- venate microbial population in soil. Mapping of soil carbon and organic matter for rice ecosystem and development of environmental impact assessment tools are a part of the government program.

There is the development of new fertiliser subsidy scheme for rice production incorporating biofertilisers and green fertilisers (the Year 2018). The other schemes for soil health improvement and enhancing nutrient use efficiency are the application of : i) organomineral with humic acid, zeolite and silica ii) coated urea and NPK granule iii) urea fertilisers with urease inhibitors iv) biofertilisers with beneficial microbes for nitrogen fixing, phosphorus & potassium solubilising The other strategies for soil health improvement being adopted are sustainable crop nutrient management through precision agriculture for rice, development of Decision Support System (DSS) tool for site-specific nutrient, organic matter and lime recommendation for rice, strategies for soft soil management in rice, problematic (peat, sandy and acid sulphate, ex- mining) soil management by improving organic matter content, R & D on rehabilitation of mangrove forest and reforestation of ex-mining soils through involvement and initiatives by various agencies in soil health management.

The Philippines country report was presented by **Pearl B. Sanchez, Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), Philippines**, who gave a presentation on the 'Soil Health and Sustainable Development Goals in the Philippines'. She elaborated on the soil health issues and informed that due to water-induced soil erosion exploitation of forest trees in the Philippines occur at a rate of 123,000 ha annually (previously recorded to as high as 210,000 ha of deforested land per year during the 1900's). Approximately 10 million ha of land are devoted to rainfed agricultural practice. Besides, 120,000 ha are bare unmanaged areas.

FAO database recorded that agricultural practice alone contributes 457 million metric tons of soil loss per year. Further, land conversion has greatly reduced the Philippines' forest cover from 70% of the area to only 22%, releasing great stocks of carbon. Lowland cultivation alone contributes 40% of the total carbon emission (as methane) in the environment. Although the country has 2.4 billion metric tons of coal reserves, 8.17 million metric tons of coal is being mined annually. Soil fertility has declined rapidly in agricultural lands. Also, 53% of irrigated rice fields in Asia have low inherent nutrient levels. In the Philippines, fertiliser use was record- ed to be rapidly increasing by as much as 100% from 1961 to 2005. Excessive soil mining caused by imbalanced use of fertilisers has resulted in soil N, P , K and even micronutrient deficiencies in most agricultural lands of the country. There is pollution of land and water resources.

Aside from agricultural practices (excessive fertiliser and pesticide application), fossil fuel combustion and mining, solid waste products also contaminate the soil with heavy metals. Currently, about 35,000 metric tons of solid wastes are generated in the Philippines daily, which are usually scrapped in open dumpsites and landfills. About 37% of the total water pollution is contributed by agricultural practice, which includes fertiliser and pesticide use.

In addition to increasing fertiliser use, pesticide application also increased by 325% (1961 to 2005), which was intensively used in vegetable production. Initiatives in soil health management include Sloping Agricultural Land Technology (SALT) System, soil conservation system employing reforestation, terracing, multiple cropping, contour farming and cover cropping, Nutrient Management while minimising impact on environment and global climate, bio-fertilisers/ microbial inoculants, slow or controlled release fertilisers, organic agriculture. Other private and government programs/policies include: Soil Conservation Guided farms, Sustainable Corn Production in Sloping Areas, Conservation Farming Village Program, Yamang Lupa Program, the introduction of National Soil Health Program Act of 2016 (House Bill 3349), Soil and Water Conservation Act of 2016 (House Bill 2587).

Challenges in dealing with soil health issues are lack of willingness to participate and adopt new agricultural practices that would promote soil health at individual /farm level, lack of local government initiatives in disseminating good practices in soil health management (extension work) at local government level, and funding constraints, ineffective information dissemination and program extension to stakeholders and lack of firm implementation of soil health related policies at the national government level. Priority areas to be addressed are promotion and implementation of soil conservation practices, best Management practices (water, nutrient and pest), organic agriculture, establishment of National Soil Health Program, guidelines for soil health assessment, soil health indicators, funding for agricultural R&D particularly in biotechnology, nanotechnology and other cutting edge technologies, firm implementation of soil health and related policies, provide incentives and rewards to farmers.

Vietnam country report was presented by **Tran Minh Tien, Ministry of Agriculture and Rural Development (MARD), Vietnam**, who made a presentation on the 'Initiatives and Priorities of Soil Health for Research and Development in Vietnam'. He showed the general agricultural status of the country and said that the major constraint is the availability of agricultural land (0.12 ha/person). Annual crops cover the major land area, dominated by paddy land. Major export value comes from wood products followed by fishery, vegetables and fruits, coffee, rice, cashew nut and rubber.

He further informed that there are 13 Major Soil Groups with 31 Soil Units dominated by Ferralitic soils (53%) followed by Alluvial soils (10%), Humus soils (10%), Grey degraded soils (6%), acid sulphate soils (6%), saline soils (3%), and sandy soils (2%). Other soils occupy 10% of land area. The pH values in the Mekong river delta, red river delta and northwest mountainous regions are mostly in the acidic range with low to medium available NPK values and low Ca, Mg, and S contents. The soils exhibit Fe content in the toxic range. There is overall degradation of soil fertility and more incidences of soil borne diseases. Improving soil health and creation of knowledge bank of soil and plant health has to be taken up on top priority.

Thailand country report was presented by **Somchai Anusontpornperm, Kasetsart University (KU), Thailand)**. He spoke on 'Regional Initiatives and Priorities of Soil Health for Research and Development: A Case of Thailand'. Based on data from the Global Assessment of Human- Induced Soil Degradation (GLASOD), he showed Global distribution of degraded soils and also the severity of human induced soil degradation in Thailand. The intensity classes of land degradation in Thailand vary from slight to severe with water erosion contributing the most (59.89%) towards land degradation followed by physical (11.80%), chemical (4.04%) and biological degradation (0.34%) affecting the average yield of major economic crops. The *Leucaena* and Vetiver grass barriers have been found effective in controlling soil erosion and have found acceptance of the farmers, particularly in the areas used for growing economic crops such as cassava, sugarcane and maize etc. In addition, the vetiver is also being effectively used to control soil erosion on road and river banks and for other soil and water conservation purposes.

On steeping mountainous areas landslide occurrence is quite common. Excessive tillage and loss of soil carbon is resulting in surface soil compaction. The development of plough pan in upland soils causes perched ground water and subsequently causing tuber rot and accelerating soil erosion due to the impediment of the pan. Further, this is disconnecting the water conducting pores and causing water deficit, retarding root elongation and tuberisation of tuber crops such as cassava owing to increased bulk density, reduced total porosity and saturated hydraulic conductivity.

There is occurrence of saline, sodic and saline-sodic soils and problem of acidification in low and upland areas that adversely affect the crop yields. Soil contamination with heavy metals and pollution problems are also quite common. He also narrated the current soil resource policy of Thai government laying emphasis on basic and translational research, research and development and implementation of policies on soil and water conservation, soil reclamation and soil improvement with Sufficiency Economy Philosophy and Sustainable Agriculture involving various line departments and educational institutions.

PNG country report was presented by **Akkinapally Ramakrishna, National Agricultural Reseach Institute (NARI) , PNG** who made a presentation on 'Soil Health Research and Development in PNG'. He informed that apart from New Guinea Island, the country has four large islands (Manus, New Ireland, New Britain, and Bougainville) and some 600 small islands lying between the Coral Sea and the South Pacific Ocean with tropical monsoon climate (annual rainfall ranging from 2500-4000 mm). Agriculture contributes 23% of GDP, 17% of GDP is from non-export agriculture and less than 10% of non-export commodities are marketed. Precursors to soil health issues are rapid population growth leading to reduced rotation length leading to fertility decline; unsustainable logging leading to erosion, fertility decline, reduced carbon stocks, loss of biodiversity; mining resulting in immediate site impacts and risks of off-site contamination; high rain fall and steep slopes leading to soil erosion; small-scale agriculture moving to steeper less suitable lands; accelerated soil erosion with plantations on marginal sloping lands; salinisation and sodification; saltwater intrusion; loss of soil biodiversity; water logging, nutrient imbalance and nutrient mining. Unsustainable cultivation practices are resulting in nutrient mining, poor nutrient conservation and nutrient imbalances.

This has resulted in overall decline in soil health, especially of soil fertility with P deficiency and acute deficiency of K and S. Some reasons for K and S deficiencies are the removal of K and S-rich vines from cropping area and leaching and out wash of K and S from ash. Phosphorus fixation in acidic soil environment is the major reason for P deficiency. The challenges of soil health management are lack of infrastructure (modern analytical and field gadgets), funding, the poor extension of new technologies, lack of farmer awareness and absence of policy support on mining, logging, plantation on marginal soils, etc.

He further spoke on the recent research initiatives like the effect of soil amendments—like cover crops, biochar, manure, and improved crop fallows on soil chemistry, soil biology, and crop productivity; effect of conventional, and mixed crop management systems on soil health; effect of long-term use of a soil management practice on soil microbial diversity; effect of soil microbial diversity, in turn, on greenhouse gas production and soil structure and the effect of long-term use of a soil management practice on the amount of atmospheric carbon sequestered in the soil.

He also elaborated the priority areas of research and development, being integrated nutrient management, legume cover crops, improved fallows, application of compost or other organic wastes, bio-fertiliser and balanced fertilisation. He emphasised on the application of improved Sloping Agricultural Land Technology (SALT) system for sustainable crop production and working together with partners to combat food insecurity and malnutrition.

Technical Session II: Climate Change, Sustainability and Value Chain
Co-chair: SS Chahal, Yu-Wen Lin
Rapporteur: V Celia Chalam

Key note Lecture: US Singh, International Rice Research Institute-South Asia Regional Centre (IRRI-SARC), Varanasi, India presented a paper on 'Sustaining Agricultural Productivity under Climate Change Scenario in Asia Pacific- Rice in SA as a case study with emphasis on policy issue'.

He presented that rice is a global staple food for more than half of humanity. Approximately 50% rice area in SA is prone to abiotic stresses like flood, drought or salinity/sodicity. Climate change is further worsening the situation. He gave a brief account of flood tolerant rice and showed the demonstrations of the Sub1 variety at various places under flood conditions. He gave a brief ac- count of several Sub1 varieties viz. Swarna-Sub1, BARI dhan-51, Swarna-Sub1, IR64-Sub1, BRRI dhan 52, BRRI dhan 79, Binadhan 11, Ciherang-Sub1, S. Mahsuri-Sub1, Binadhan 12, Samba-Sub1/Binadhan 12, CR1009-Sub1 released in S. Asia from the year 2009 to 2017 in India, Bangladesh and Nepal. Similarly for drought tolerance he explained the situation of drought in rice growing areaslike flood drought causing severe losses to farmers. Annually 25-30 m ha of rainfed rice experiences the drought. The drought tolerant varieties viz. Sukha dhan 3, BRRI dhan 56, Sahbhagi Dhan were released in Nepal, Bangladesh and India, respectively. Salt- tolerant rice needs to be developed as salt stress is affecting more than 16 m ha in Asia. Therefore, salt tolerant land races were identified and are being used to breed tolerant varieties. Mark ers were developed for major loci and are being used for MABC and forward breeding. New salt tolerant varieties viz., BRRI Dhan 47, CSR43 were released in Bangladesh and India respectively. Multiple stress tolerant rice varieties viz., Bahuguni 1, Bahuguni 2, CR dhan 801, DRR dhan 50 were released in Nepal and India. The role of IRRI was to act as catalytic, and to follow-up varieties released by 775 partners in India, Bangladesh and Nepal.

Pre-release promotion and seed multiplication, seed minikits, large demonstrations and seed production, Head to Head Trials, Crop Cafeteria, Demos through retailers, Crop insurance-linked promotion: pipeline and Seed entrepreneurship need to be undertaken. Seed policies and regional cooperation in the seed sector is very important to speed up the process of varietal release, create awareness and demand, The Kathmandu Agreement was signed by Bangladesh,

India, Nepal & IRRI and three countries agreed to share the evaluation data and varieties released in their respective countries for release and commercialization in the other two countries. Under this programme, India released four varieties from Bangladesh and two from Nepal and Nepal released two varieties from India. He further explained about Seed Without

Borders, Siem Reap Agreement (10 June 2017): The agreement was signed by Bangladesh, Bhutan, Cambodia, India, IRRI, Nepal, Sri Lanka and Myanmar to recognize each others' seed certification system. Also spoke about extended Dhaka and Kathmandu agreements to include other crops like other cereals, pulses, oil seeds, vegetables, sugarcane and fiber crops. It was felt worthwhile to include private sector rice varieties and extending an agreement to more countries particularly in Africa to meet out the food requirement of people world over.

Jainz S Binamira, Consultant, Department of Agriculture, the Philippines, spoke on 'Asian Farmers: Soil Health Champions in Asia' and shared the FAO Policy recommendations on the ASEAN Guidelines on Soil and Nutrient Management as well as the Philippine experience on how to move forward towards making ASEAN Farmers as the Soil Health Champions in Asia. He narrated that Asian agriculture today faces the double challenge of feeding a growing population while decreasing its environmental impacts. About 12% of the population of Asia or 520 million people are undernourished. Further, 70% of all malnourished children in the world live in this region. Asian agriculture is most affected by land degradation with more than 1 billion people live in degrading agricultural areas. The sector is characterised by intensive agriculture systems with high environmental impacts of food production. The Green Revolution started in Southeast Asia in the 1960s and still shapes its agricultural sector today. The Green Revolution introduced technology packages consisting: modern but fertiliser dependent crop varieties, agrochemicals, irrigation and mechanisation which made possible intensive crop cultivation- two or three crops annually. As a result, staple food production doubled in the ASEAN region with positive outcomes for national and regional food security.

Impressive production gains of the last 50 years, however, came with high environmental costs. Soils in particular were adversely affected. About 1 Billion tons of top soil is lost annually in ASEAN member states. Over three- quarters of the land resources in Malaysia, Brunei, the Philippines, Thailand and Vietnam are now classified under severe and very severe degradation due to unsustainable agricultural practices and changes n climate change mitigation since soils represent the largest carbon sink on earth. Reducing soil degradation and implementing sustainable soil management are cross-cutting issues, critical for food security, ecosystem stability and climate change mitigation. He mentioned about ASEAN Guidelines on Soil and Nutrient Management (ASEAN- GSNM). Cognizant of the functions that are crucial for the provision of ecosystem services to society- particularly through the large biodiversity hosted within soils. Soils are a valuable ally iage soils, nutrients, water and crops in a sustainable manner; and particularly acknowledges the importance of Soil Health that needs to be understood as a holistic approach to enhance the provision of ecosystem services and proposes a framework to implement site-specific nutrient and soil management practices.

The ASEAN GSNM contains a menu of technology packages consisting of Good Soil Management Practices and Good Nutrient Management Practices, among others. Based on the Fertility Capability Classification maps, Site and Soil Specific Nutrient Management or SSNM methodologies are tailored to specific conditions and delivered through the Thai-developed Soils Doctor Program and other Integrated Communication Technologies. Severe soil degradation in the region, ASEAN policymakers have begun to pay more attention to sustainable agricultural systems based on managing soils according to their specific constraints. The rehabilitation of the productive capacity of soils is key issues addressed in the ASEAN Sustainable Agrifood Systems. The ASEAN GSNM represents a timely effort at guaranteeing healthy soils as a means to tackle food insecurity, mitigate and adapt to climate change and conserve biodiversity in ASEAN Member States.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)-supported Guidelines was developed by soil experts from the 10 ASEAN member states with Thailand as lead convenor. The ASEAN-GSNM aims to achieve food security by promoting adaptive and resilient 'climate-smart' agricultural systems, while maintaining the functional capacity of the soil resource to provide essential ecosystem functions, including mitigation of emissions of greenhouse gases.

The Guidelines recognise soil and nutrient management as an integrated system to manage soils, nutrients, water and crops in a sustainable manner; and particularly acknowledges the importance of Soil Health that needs to be understood as a holistic approach to enhance the provision of ecosystem services and propos- es a framework to implement site-specific nutrient and soil management practices. The ASEAN GSNM contains a menu of technology packages consisting of Good Soil

Management Practices and Good Nutrient Management Practices, among others. Based on the Fertility Capability Clas- sification maps, Site and Soil Specific Nutrient Management or SSNM methodologies are tailored to specific conditions and delivered through the Thai-developed Soils Doctor Program and other Integrated Communication Technologies. ASEAN, however, recognises that the Guidelines should NOT remain on book shelves and that comprehensive programs involving training and capacity building are undertaken, and that governments are vocal and effectively advocates upscaling Soil Health in the region.

This Calls for the empowerment of ASEAN farmers as Soil Health champions, through capacity building based on participatory and interactive learning processes, and local testing towards the customisation of technological packages. Healthy soils are the foundation for productive and sustainable agriculture. Soil Health Champions must work with their land – not against – to reduce erosion, maximise water infiltration, improve nutrient cycling, save money on inputs, and ultimately improve the resiliency of their working land. For 50 years, however, the GR taught farmers the use of pesticides as the only way to grow a healthy crop. For 50 years, the GR told farmers to use chemical fertilisers to increase productivity. To create Soil Champions among ASEAN farmers, however, two things are imperative. The paradigm shift has to be there which viewed soils as a lifeless medium to be supplied with nutrients and water to produce crops. Conversely, the concept of 'Soil Health' acknowledges the ecological role of soils and the contribution of biological processes. Farmers are often familiar with the physical and chemical characteristics of Soil Health; but not biological soil health, nor the eco- system services that soils deliver. A growing number of farmers, for one, use organic fertilisers but this practice is driven from limited financial resources to buy chemical fertilisers or of meet- ing organic market standards rather than maintaining soil health. Healthy soils provide a living environment for the soil food web. The Food Web is composed of a community of organisms living all or part of their lives in the soil. They are fueled by the primary producers that use the sun's energy to fix carbon dioxide from the atmosphere. And as organisms decompose complex materials, or consume other organisms, nutrients are converted from one form to another, and are made available to plants and to other soil organisms. Fostering soil health means exploring and adapting practices that enhance ecological processes at both the field and landscape levels. These practices are much more knowledge-intensive and require investments in quality farmer educa- tion, an education that enables farmers to create new knowledge and not simply knowledge- transfer. Rural education programs must create spaces that allow farmers and researchers to use complimentary local and scientific knowledge to test farmers' own context-specific solutions while improving their knowledge on soil functions and ecological processes. Integrating Farmer Field Schools (FFSs) into the framework of the ASEAN-GSNM means enabling farmers to create new knowledge MEANS using Farmer Field Schools in upscaling Soil Health.

The FFSs do not make farmers into Soil Health Experts, but rather they develop them to be experts in their fields or landscapes. FFSs do not provide answers to farmers, rather, through FFSs, farmers learn how to look for answers – they learn how to ask the right questions, and how to do experiments in a scientific way. FFSs focus on developing farmers skills: Management and decision-making skills on agronomic and ecological factors; Critical skills that enable farmers to identify and analyse problems and take action; Leadership skills in facilitating group learning activities and prob- lem-solving processes. FFSs used three equally important Non-Formal Education methods: Dis- covery-based learning which is an inquiry-based learning that takes place in problem solving situations where farmers draw on their own past experience and existing knowledge to discover facts and relationships and new truths to be learnt (questions, not answers), experiential learning whereby new knowledge is created through the transformation of experiences shared by farmers. Participatory approaches to actively engage farmers in decision-making processes. FFSs were first developed in Indonesia by FAO to address the pest problems in rice and the non-judicious use of pesticides. There are FFSs now in Cambodia, Lao PDR, Myanmar, Thailand, the Philip- pines, Vietnam as well as in other countries in Asia, Africa, South America, and Eastern Europe. An FFS is a season-long training of 25-30 farmers, from planting to harvesting or post-harvesting – and the classroom is the field.

Three activities underlie a quality Farmer Field School: Agro-Ecosystem Analysis, Group Dynamics & Special Topics. As a first FFS activity, farmers undertake Agro-Ecosystem Analysis, discuss and process their observations and present their findings and conclusions to the bigger group. This activity shows farmers the role of field observations and analysis of agroecosystem elements as the bases for informed decision-making while enhancing their critical thinking and problem-solving skills. The second major activity of an FFS builds trust and self-confidence among farmers to share their experiences necessary to create new knowledge. Farmers are usually reluctant to talk and share in big groups. Group dynamics activities promote knowledge sharing, team building, and other aspects of working together with a common goal. The third FFS activity consists of Special Topics consisting of discovery-based exercises and experiments undertaken to address specific technical issues or to deepen farmers' knowledge on particular farming or ecological aspects.

Farmers decide on the special topics that will be taken up in the Farmer Field Schools. From experiences around the ASEAN region, FFSs facilitated the adaptation and modification of farm management practices resulting from collective learning processes and experimentations. From experiences on Integrated Pest Management (IPM) in FFSs in the Philippines, farmer-led experimentations have developed farmers' problem-solving skills, integrating scientific knowledge into local knowledge systems and adapting practices to the specific socio-economic context. Farmers' knowledge and skills acquired through discovery learning methodologies are crucial to tailor and upscale sustainable, knowledge-intensive farming practices, such as IPM, Organic Agriculture, Agroforestry, and Agro-Ecology. During the 60s, the Government gave away insecticides and sprayers so farmers could use pesticides to protect their rice crops. The Green Revolution provided subsidies and farm credit to farmers, resulting in a significant increase in the average use of in- secticides of 1.0 kg a.i./ hectare. With the declaration of IPM as the national crop protection strategy and the training of more than 350,000 farmers in FFSs, average insecticide use in major rice-producing provinces significantly decreased to 0.1 kg a.i./hectare, even less than their average usage in the sixties. Our experiences in IPM have shown that FFSs can also mainstream Soil Health into farmers' common knowledge, and, in this regard: FAO proposes the integration of FFSs into the implementation framework of the ASEAN-GSNM.

With FAO's support and guid- ance, and the participation of Indonesia and Lao PDR in the development process, the Philip- pines conducted pilot FFS on Soil Health in six provinces in the Visayas and Mindanao. The building of FFSs on Save and Grow, the pilot FFSs on Soil Health was a first attempt to promote a holistic approach of soil management and adopt sustainable soil management practices to local conditions through discovery-based learning processes. Through field experimentation, FFS far- mers tested and validated the ASEAN-GSNM recommendations for sustainable soil management practices. These included Good Soil and Nutrient Management Practices such as the use of cover crops, crop rotation, conservation agriculture, System of Rice Intensification or SRI, managing soil constraints, and the use of organic, inorganic and bio-fertilisers. A new FFS Field Guide and Curriculum, with field studies and exercises on Soil Health,- a first in the world, was designed and validated with FFS farmers, facilitators and Soil Health experts from FAO, the Bureau of Soils and Water Management and the Philippine Rice Research Institute. In particular, a new Agro-ecosystem Analysis module was developed which covered the root system, including the soil ecosystem. Field studies and participatory action research guides were likewise developed and validated to enable farmers to understand soil health concepts, particularly biological soil health and soil ecosystem functions. ASEAN-GSNM recommended Good Soil and Nutrient Management Practices were "localized" and validated. The Philippine proposal is proposing to the ASEAN Working Group on Agricultural Training and Extension to upscale Soil Health and the making of Soil Health Champions in ASEAN through the FFSs. In ending, he said, allow me to leave you with a quote from an Indian tribe leader (Muhsin Tropak): We did not inherit this world from our ancestors, we only borrowed it from our children. And as we make this world into a harmful place with our irresponsible approaches, we will leave an uninhabitable world to them.

Girish Chander, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India made his presentation on 'Soil Health Management- Issues & Concerns for Sustainable Development'. He referred to soil degradation as one of the major issues because of which there are large yield gaps in dry lands and challenging food and nutritional security. It is important to strengthen the agriculture-based livelihoods for sustainability and resilience-building to face the challenges of climatic variability. Due to widespread soil degradation there are widespread deficiencies of macro, micro & secondary nutrients and severe depletion of organic carbon in soils resulting in low input use efficiency that threatens sustainability. Due to lack of awareness there is imbalanced & uneconomic fertiliser use. Individual nutrient deficiencies are scattered differently and precise fertiliser management is needed. There is great scope to scale up in horticultural plantation along with agricultural crops with crop specific recommendations for secondary & micro nutrients; need to fix up critical soil nutrient limits- soil/agro-ecoregion-wise. He pointed out that soil test-based management is a low hanging technology and one of the best entry point activity; being knowledge-based and involves participatory research and development

(PR&D) approach, with high success probability (>80-90%), results in the measurable tangible economic benefits to the farming community with a relatively high benefit: cost, simple and easy for the participating farmers and reliable and cost-effective approach to assess the constraints. He presented successful case studies on soil test based balanced nutrient management from some states of India.

He further referred to carbon-sequestration as adaptation and mitigation strategy to climate change as huge scope exists of recycling on-farm wastes through composting – microbial consortia cultures, vermicomposting etc. for improving soil microbial health; plugging nutrient losses through watershed approach and soil salinity and amendments for sustainability. Need for creating centralised state of the art infrastructure for analysing soil, water, plants and fertilisers district wise, upgradation of selected labs in the regions as referral labs and Options for public-private partnership to run the referral laboratories was also emphasised.

Bunjirtluk Jintaridth, Department of Agriculture, Bangkok spoke on the 'Soil Health for Research and Development'. She said that our soils are under threat as there are many drivers of soil degradation, different types of soil degradation, and serious consequences of soil degradation. Sustainable soil management is the only solution to face these challenges. She highlighted the importance of soil physical, chemical and biological health management for modern agriculture and to ascertain as to whether the practices provide good soil quality and soil health. She also gave examples of some practices with output and outcome as bad and good for soil quality and soil health. She referred about the visual assessments and assessment based on soil analysis for soil health; standard nutrient analysis for heavy metal contamination, salinity, carbon, etc, soil microbial population, soil enzymes, soil protein index, soil respiration, etc.; land management strategies, planning, framework, options with land management goals.

She dealt in detail about the future soil health requirements which should concentrate on practices like no-till, cover cropping, diverse rotations, increasing soil organic matter, improving microbial activity, sequestering more carbon, increasing water infiltration, improving wildlife, pollinator habitat, tillage intensity, tillage system, local cropping system, biological products, crop rotation, etc. to cope up with the challenges of climate change with an objective of more carbon sequestration, plant breeding (rhizosphere), sustainable land management, soil survey, soil health scoring assessment etc. The Key of Success, he said, is "To enhance soil quality and agricultural productivity while promoting long term sustainability base on participatory principle". Several activities for promoting Sustainable Land Management (SLM) and soil health are Decision Support for Mainstreaming and Scaling up for Land Management (DS-SLM), Asian Soil Partnership (ASP) and observing World Soil Day (WSD). She also talked about the operational strategy and action plan for mainstreaming and scaling out SLM.

Pradeep K Sharma, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), India spoke on 'Soil as a Carbon Sink'. He listed the implications of Global Warming and Climate Change as glacial melting, flash floods, sea-level rise, extreme weather events, snow, rains, cloud bursts, floods, wildfires, droughts, tropical storms, new pests & diseases outbreaks, loss of soil health, reduced agricultural productivity, loss of agricultural products, loss of biodiversity, green house gases (GHGs) emission, increasing CO_2 levels, etc. and referred to increasing GHG emissions as the primary cause of global warming (CO_2 alone expected to be 541- 970 ppm by the year 2100). Soil C sequestration, he said, is a natural process where atmospheric carbon (CO_2) captured by plants through photosynthesis is returned to the soil as organic matter for safe storage over a long period. This depends upon land use, quality and quantity of C inputs, soil C saturation, C stabilisation etc. Soil order, soil properties like finer soil fractions chemical composition of the material and rate of decomposition determine the soil C sequestration.

Further, over a short period of time there is a linear relationship between C input rate and soil C build-up. However, the fraction of the added C retained by a given soil decreases with the increase in C supply rates. He also said that C inputs must be above the maintenance levels and the critical maintenance levels may vary between 1.1 and 3.5 C Mg $ha^{-1}y^{-1}$ depending on soil types and production systems. Supply rates to cause soil C storage is higher in organic matter (OM) rich than in OM poor soils. He further talked about the steady-state and C saturation concept that increased input with time results in increase in C content but once with time a saturation point reaches then increased input may not result in additional soil carbon. The potential to change soil C as well as soil C capacity depends on the balance between C inputs and outputs in a given environment. He referred to three pools of stabilised soil organic matter (SOM) viz., chemically stabilised carbon, physically stabilised carbon and, biochemically stabilised carbon, soil C stabilisation through aggregation and preferential sequestration of

C in the micro-aggregates, use of recalcitrant material like bio-char for C Sequestration and finally he said that computer models indicate that projected annual global emissions during the next century would need to be reduced by more than 75% in order to stabilise atmospheric CO2 at about 550 ppm, which is the concen- tration about twice the level of CO2 in the pre-industrial atmosphere.

Suseelendra Desai, ICAR-Central Research Institute for Dryland Agriculture (CRIDA), India presented a paper on 'Potential Impacts of Climate Change on Plant Pathogens & Biocontrol Agents and Adaptation Strategies'. He highlighted the impact of climate change on crop and emerging diseases particularly wheat rust, blast in rice; *Fusarium oxysporum* f. sp. *cubense* TR4 in banana, etc. which have caused considerable losses, while *Alternaria* blight and *Phytophthora* blight of pigeonpea and many more are the emerging diseases. To meet the challenges of climate change the attention should be given for host plant resistance by exploring genetic resources, de- veloping suitable agronomic practices, Integrated Disease Management (IDM) modules, etc.

He emphasized the need for regional collaborations for strengthening climate change research in plant protection and explained Current Networking in Climate Change Research wherein 40 ICAR institutes across all sectors of agriculture have created National Innovations in Climate Resilient Agriculture (NICRA); NRM module, Pest & disease dynamics, Agricultural Contingency plans for weather-induced pest losses and their management plans were prepared with ICAR, SAUs, KVKs, line departments and other national and international collaborations i.e. novel disease management strategies; understanding disease dynamics; abiotic stress tolerance through beneficial microbes; harnessing microbial diversity are some of the measures to fight the challenges of climate change. Simulation modelling for risk assessment and management; host- pathogen interactions and extreme weather events; climatic analogs should be given priority. He concluded his talk with the opinion that under changing climate conditions, strong survey and surveillance are required to track the shift in pathogen population and well-planned modelling studies can help to understand interaction among multiple biological phenomena and there is urgent need for regional/global collaborations, etc.

Himanshu Pathak, ICAR- National Rice Research Institute (NRRI), India made his presentation on 'Role of Soil Health in Achieving the Sustainable Development Goals'. He emphasised the role of soil health in meeting the SDGs and said that for developing countries, the SDGs are very crucial and we must not miss the target, which we did for the MDGs. Soil and civilisation and soil and society are interlinked as healthy soil produces healthy food, healthy soil requires less external inputs, healthy soil keeps environment healthy, healthy soil reduces dependence on other countries for food, and it is possible to manage and maintain good soil health. He further talked about the physical, chemical and biological attributes of soil health which apart from many other processes regulates biodiversity, nutrient cycling, degradation of pollutants and trace gas emissions and there are many driving forces and threats which are affecting the soil health which ultimately results in yield loss, low input efficiency, poor crop quality, reduce income, pollution and climate change. Mitigation methods like C sequestration, conservation agricul- ture, Integrated Nutrient Management (INM), erosion control, diversification and amelioration of salt-affected soils were discussed.

He also pointed out that as per estimates 24 to 40 million tons more grains could be produced every year in Africa, Asia and South America by storing one ton of organic matter per hectare of land. He further referred to the threats of imbalanced nutrient use as poor air, water and soil quality which causes green house imbalance. Global mean temperature increased ~1° C, and is expected to increase further by 3.7 to 4.8°C by 2100. With this increase, the frequency and intensity of climatic extremes will increase. The world is getting 50% of rain- fall in 12 days, and sea level to rise by ~50 cm by 2100 if control measures are not adopted. He also referred to the extent of green house gas (GHG) emissions and agriculture. In 2017, the world emitted ~65 billion tons CO2 eq. Globally, agriculture contributes 10-12%, whereas Forestry and Other Land Uses (AFOLU) contribute about 24-25%. In Asia, agriculture contributes ~20%, AFOLU 30-35% whereas Indian agriculture contributes ~1% of global GHGs. He also discussed various ways and means to improve the soil health which is directly linked with soil organic carbon built-up, efficient nutrient management and soil management which should enhance the efficiency and reduce the emission to achieve the SDGs. Finally he showed the trends in GHGs emission from Indian agriculture and pointed out that from 1970 to 2015, GHGs emission per ha has almost doubled, but per ton food grain production decreased by 20%. The chal- lenges of managing soil health being deteriorating soil health, slow adoption of resilient technologies, lack of agreement on policy at national and international levels, fragmented research and development activities and inadequate expertise of researchers and policy makers. An integrated effort such as "Global Soil Partnership" is needed in managing soil health for achieving the SDGs.

Sivapragasam Annamalai, Centre for Agriculture and Bioscience International (CABI), Malaysia presented a paper on CABI's Role in Strengthening Plant Health along the Agricultural Value Chain by giving a short introduction about CABI and its strategic priorities linked to SDGs with the objectives of Global Scientific Publishing; Knowledge Management (Digital Development and Data); Trade and Commodities (Value Chains); Invasive Species; Development, Communications and Extension; Plantwise and Bioscience (Microbial and Molecular Services). He explained the role of CABI in the agricultural value chain for the benefit of all the stakeholders. CABI's goals and activities were highlighted as to 'Enhanced productivity and quality of produce, sustainability and climate resilience of farming system; Improve access to the market through enhancing business skills of the value chain (especially small holders) and availing of market information and; a vibrant value chain and trade portfolio with a secure future. He ex- plained about CABI and plant health systems such as Plantwise and given details such as 1743 Plant clinics piloted in 34 countries, 4988 plant doctors trained and 4.5 million farmers reached.

He explained the achievement of the horticulture value chain developed in target areas in China, New Zealand, Pakistan, India and Vietnam. He explained the success of the projects in China: Kiwi fruit pest management; Pakistan: Strengthening Vegetable Value Chain in Pakistan (SVVCP), Value Chain Technical Assistance Team (VCTAT); India: Unilever project; Vietnam: Innovative and market-oriented IPM of dragon fruit, mango and litchi, wherein farmers trained were 7,000; 8 expos in Pakistan; 16 single country promotions; Participated in 11 international expos. However, there were many success stories as in China: Biocontrol of Brown Mammorated Stink Bug in kiwi fruit orchards; Pakistan: In three years under VCTAT, 250,000 acre Good Agricultural Practices (GAP) compliance, 40,000 acre GAP certified, 80 processors and 20 traders certified.

M Anandaraj, Ex-ICAR-Indian Institute of Spices Research (IISR), India presented a paper on 'Microbes for Improving Soil and Plant Health in Spice Crops'. India is known as land of spices and every region has its own spice to boast. 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 needs, 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 as described in other cases of PGPR and *Trichoderma* spp. 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 seed coating and bio-capsules 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 colonisation. 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 Bio-capsule technology, the volume is reduced by one hundred times as in place of 1kg talcum formulation a mere ten capsules can be used. He discussed the success of this technology.

Technical Session III: Regional Initiatives and Priorities of Plant Health for Research and Development
Co-chairs: AN Mukhopadhyay, Srinivasan Ramasamy
Rapporteur: VK Baranwal

South Asia

Bangladesh country report was presented by **Dilwar Ahmed Choudhury, BARI, Bangladesh, on 'Plant Health Management in Bangladesh**: Issues, Present Scenario and Future Needs'. He explained the scenario of agriculture where in due course of time production of rice jumped to 3.5 times and in wheat 11 times to achieve self sufficiency in food production. He explained the recent pest management scenario was indiscriminate use of synthetic toxic chemical pesticides (misuse and overuse, use of impure and improper, non-registered or sometimes banned pesticides) is a common scenario especially in the high valued crops, viz. some vegetables and fruit crops. Consequently there is pesticide resistance in brinjal fruit & shoot borer, country bean pod borer *Helicoverpa armigera* and outbreak of pests viz. *Spodoptera litura* in bitter gourd, chilli, mungbean, okra, tomato, etc. Similarly, the quarantine pests viz. papaya mealy bug, tube spittle bug in ber, Ber nut weevil, red banded caterpillar (fruit borer), giant mealy bug attack was found in the crops. The threat of new pests viz. tomato leaf miner *Tuta absoluta*, outbreak of flea beetle, *Phyllotreta* sp. in different crucifers; Incidence of fall armyworm in maize and wheat blast were the serious problems in the crops.

He gave the priority areas of pest management as per SDG 2, 4 and 3, i.e.by 2030 the country should ensure sustainable food production and implement resilient agricultural practices. The target is fixed for identification of destructive insect pests and diseases emerged as threat due to global warming and IPM/ IDM approaches for sustainable management instead of existing chemical pesticide-based system.

To meet the challenges of new emerging pests, IPM technologies including bio-pesticides, botanicals and resistant varieties against the pests were developed in brinjal and later on in 22 different crops viz. bitter gourd, sweet gourd, ridge gourd, tassel gourd, cucumber, watermelon, cabbage, cauliflower, chili, tomato, mango, guava, litchi, etc.

Thrust areas for pest management are regional collaboration for strengthening GAP and safe food production; resistance breeding against pests; IPM research; strengthening of phytosanitary rules and regulations and management of new pests, motivation and awareness-building activities for rational use of pesticides and safeguard natural resources (land, soil, water and biodiversity).

CD Mayee, South Asia Biotech Centre, India presented a paper on 'Indian Agriculture: Current Challenges, New Opportunities and Technological Options'. He discussed the transformation in Indian agriculture since the green revolution era in India. Like other Asia-pacific countries agriculture in India is facing the challenges of small land holdings, population growth, shrinking land, water resources, climate change, changing food habits, acceptance of newer technologies, low investment in science, slow pace of public private partnership etc.

According to an estimate the population of the country will be 1.78 b and the country will need 333 m t food production. The existing system has not been translated into effective pest management due to lack of coordination between State Agricultural Universities (SAUs), ICAR Institutes and State Department of Agriculture; slack pesticide industry: pesticides registered in India (241), Pakistan (495), USA (755). There was sale of spurious pesticides that has a huge market and also occasional lacing of bio-products with chemicals, no check; Label claims not properly adhered too; Pesticide residues are above maximum Residue Limits (MRL) and health hazards and judicious use are rarely taken care as part of education.

Emerging and chronic diseases of crops are wheat blast, Ug 99 and yellow rust of wheat. He advised that there is a need to respect farm biosecurity, and one should adopt the strategy of COME CLEAN and GO CLEAN. He suggested practicing IPM strategies for pest management. IPM is a holistic approach to sustainable agriculture that focuses on managing pests through a combination of cost effective, environmentally sound and socially acceptable strategies. A package of IPM for 89 crops that exist on the website of Department of Agriculture, Cooperation & Farmers Welfare, Govt. of India should be consulted and practiced. Indiscriminate use of pesticides, purious pesticides and lack of registration/ off-label use of pesticides are the concerns. He also discussed CRISPR-Cas9 technology and India needs to have regulations in place for products developed by CRISPR-Cas9 technology.

Nepal country report was presented by **Deepak Bhandari, NARC, Nepal** on 'Issues and Priorities of Plant Health for Research and Development in Nepal'. He gave the introduction of agriculture in the country, where more than 65% of the population depend on agriculture. More than 10% yield losses (estimated) are caused by plant health-related problems. The country is having huge diversity of climate, plants and pests.

Therefore many crops, vegetables and fruits can be grown which have the threat of various insect pests and diseases. Major plant diseases are blast of rice; grey leaf spot in maize, stripe rust in wheat, *Stemphylum* in lentil; late blight in potato; citrus greening; banana wilt and virus diseases. Major issues and challenges of plant health are lack of updating of data due to the absence of survey and surveillance; weak coordination among stakeholders; unjustified use of pesticides including lack of availability of newer pesticides and irrational use of pesticides vs no use of pesticides; lack of trained human resource and advance equipment; brain drain; low use of biotechnological tools; impact of climate change which is severe in hills; shifting of insect pests and diseases; emergence of new diseases and races; weak quarantine; lack of National policy on agriculture; Low priority to agriculture and need for Regional plant protection laboratory.

The prioritized research strategies for plant health are listed as: Development of resistant varieties; Integrated disease/pest management; New initiatives in extension for plant health viz., awareness creation, weekly climate-based advisory bulletin, Farmers field schools, chemical residue analysis labs, bio-pesticide factory etc.

Sri Lanka country report was presented by Ganga Devi Sinniah, SLCARP, Sri Lanka on 'Initiatives and Priorities of Plant Health for Research and Development in Sri Lanka'. The important crops cultivated are rice, rubber, tea, coconut, mixed coconut and rice, sugarcane, fruits, vegetables, flowers, etc. Major insect pests and diseases in Sri Lanka are Cnaphalocrosis medinalis (5- 25%), *Magnaporthe grisea,, Aceria guerreronis, Rhyncophorus ferrugineus, Exobasidium vexans*, borers, thrips, leaf hoppers, aphids, viruses , nematodes, anthracnose, bacterial-fungal rot and forest die-back in different crops. Challenges in ensuring plant health are: changes in climate and weather pattern, food safety requirements and trade agreements, pesticide regulation and ban of chemicals including availability of fewer new chemicals, lack of coordinated efforts in R & D, policies, capacity building and extension activities, inadequate adoption of IPM technologies, and financial and resource constraints.

Government initiatives to ensure plant health are national regulations including Acts; National Committee on Plant Protection; National pest surveillance system; National agriculture policy promoting IPM; organic farming; bio-pesticides; post-harvest technologies; enforcing phytosanitary measures; International collaborative programs to strengthen extension with CABI, and promoting ICT application e-surveillance. Private sector initiatives in this direction were: Importing, formulating and distributing a range of agrochemicals and agro machinery; Involvement in pest diagnosis & monitoring; Pesticide monitoring and analytical laboratory facilities; General pest management, fumigation activities; Organic farming, E- extension, R & D activities. She proposed priority areas in R&D including the use of biological and non-chemical control methods in pest management, breeding of resistant crop varieties, strengthening IPM, Good Agricultural Practices (GAP) and minimising the use of chemical pesticides, use of 'omics' in plant protection, climate change and its effect on insect pests and diseases, Pest monitoring and forecasting, post-harvest technology and use of bio-technology, Geographical Information System technology and nanotechnology for efficient pest management. The priority areas in policy have been discussed and are: Framework and capacity for management of pests of national significance; strengthening national research, education and training capacity to ensure cost effective, efficient and sustainable pest management; encouraging the development and implementation of strategic plans for disease management at all levels and implementation of phytosanitary measures.

South East Asia and Pacific

Japan country report was presented by Naruo Matsumoto, JIRCAS, Japan on the 'Regional Initiatives and Priorities of Plant Health for Research and Development in Japan'. He presented the activities being undertaken in plant health in Japan as healthy seed production; tolerant variety development; prevention of pest infection and insect outbreak and strict implementation of plant quarantine. In healthy seed production, the emphasis is given to seed disinfection by high temperature and chemical treatments; seedling facility disinfection and availability of pest detection kit. To develop tolerant variety, collecting and selecting tolerant plants; determining the target, marker development and use of appropriate breeding technique is important. In case of prevention of pest infection and insect outbreak the emphasis is laid on the elucidation of life cycle, habitat, movement of pests and infection mechanisms; survey and evaluation techniques, use of pesticides/ fungicides and natural enemies. In plant quarantine, efforts are being made to prevent the entry of harmful pests from overseas and plant quarantine inspection of plants transported as cargo, carried in personal baggage, sent via postal mail or transported by other means is carried out strictly.

Taiwan country report was presented by **Yu-Wen Lin, Council of Agriculture, TARI, Taiwan** on 'Experiences of Research and Development of Technologies on Soil and Plant Health Management in Taiwan'. He presented the plant health issues of crops including insect pests and diseases, pesticide residues, the impact of extreme weather such as drought, flooding, storm, abnormal temperature, etc. The challenges are to make a balance among profitability and environment quality/ food safety; conflicts between soil regulations and food regulations; public communication/ education and availability of funds. Dr Lin emphasized on Integrated Pest Management including cleanliness of the field; use of protective facility; production of disease-free seedlings; application of appropriate fertiliser at appropriate rate, ratio and at appropriate time and proper water management. She also discussed monitoring of population dynamics of pests, rational use of pesticides, pre-harvest and post-harvest treatment of agricultural produce, etc. In case of production of disease-free seedlings, tissue culture for mass propagation of disease-free seedlings of asparagus bean, potato, sweet potato, papaya, citrus, strawberry, passion fruit, green onion, etc. are undertaken. For rational use of pesticide, right chemical at right time at right concentration with appropriate methods are used. Natural enemies are taken into account for pests management. For non-chemical methods, microbial agent for controlling the diseases and insect pests and non-chemical materials viz. phosphoric acid, seed oil, combination of lime and sulfur, combination of seed oil and essential oils, etc. are used. Mass rearing of the natural enemies of insect pest management is done at a large scale to make it available to the farmers.

Philippines country report was presented by **Anthony B Obligado, Bureau of Agricultural Research (BAR), Philippines** on the 'Regional Initiatives and Priorities on Plant Health in Philippines'. He narrated important crops, their plant health issues and challenges for their management. The challenges in the crops were: diseases: *Fusarium* wilt and *Abaca bunchy top virus* (ABTV) affecting abaca and utilisation of infected planting material aggravates the disease. Therefore, emphasis is given for the use of tissue culture planting material which is still limited.

Cacao crop is affected by cacao pod borer and integrated pest and disease biocontrol management strategies have been suggested for the farmers. Vegetable crops suffer from *Fusarium* wilt and bacterial wilt. Fruit crops are affected by insect pests and diseases and there is abuse on pesticide application. There is a large scale abuse of pesticide application. Corn suffers from corn borer and hybrid technology is available but expensive. N corn, Bio-N technology is available to the farmers. Intensive crop cultivation depletes soil nutrition and results in soil sickness and infection of the crops with pests due to poor status of nutrients. In cassava, the crop is affected by arthropod pest and diseases and low nutrient condition of the plantation areas is a challenge.

He discussed various technologies developed and supplied to farmers including entomopathogens, *Lecanicillium lecanii* and *Metarrhizium* sp. are used for the biological control of the aphid which is the vector of ABTV; alternative nutrient management strategy for abaca; viable tissue culture-based technology of producing clean planting material of yam for seed growers and farmers; integrated nutrient management for increased cacao productivity in the region; cacao varieties adapted to local agro-climatic conditions of region 02 (BR25, UF18, PBC123 and ICS40) were identified productive due to the large number of harvested pods per tree, resistance to diseases and resistance to prolong drought; recommended varieties of Robusta and Liberica coffee were introduced as new plantings to improve coffee production. Integration of bending and multiple stem technologies in the newly planted coffee were also employed to increase yield.

For the old and unproductive coffee orchard, rejuvenation technology and its POT was introduced to rehabilitate and revive the coffee orchards; farmer selected improved GCTCV genotype(s) with better yield and agronomic traits, disease resistance (*Fusarium* wilt), fruit quality and marketability of banana, etc. In cassava, developed database on insect pests and diseases and cassava peel to con- trol pests. Also, developed eco-friendly insect pest and disease management strategies.

Thailand country report was presented by **Pattara Opadith, Department of Agriculture, Thailand** on 'Regional priorities of plant health for research and development in Thailand'. To protect plant health, implementation of WTO/ SPS, FAO/ IPPC, FAO/ APPPC for transboundary pest management, implementation of sustainable crop production programs, integrated pest management (IPM) and Good Agricultural Practices (GAP) in relation to food security were discussed. APPPC was discussed with its purpose for harmonisation and cooperation of phytosanitary measures among Asia-Pacific region. Presently there are 25 Member countries in which Thailand joined in 2010. Plant health is protected through IPM, pesticide management and plant quarantine. She told about the Plant Protection Act in Thailand viz. Plant Quarantine Act B.E. 2507(1964), subsequently amended in 1999 and 2008. He gave out the sketch of the Department of agriculture for implementing plant health and related agriculture development. Plant Quarantine operation includes Agricultural Regulation Office, Plant Protection Research and Development Office for technical support. Plant quarantine is implemented by 42 quarantine stations located in north, south, central, east, central and northeast. Plant quarantine research group include Plant Diagnostic Quarantine Pest Section, Pest Risk Analysis Section, Plant Quarantine Treatment Section and Plant Pest Surveillance Section. To protect invasive species such as yellow- spined bamboo locust (*Ceracris kiangsu*), tomato leaf miner (*Tuta absoluta*), cassava green mite (*Mononychellus tanajoa*) stringent inspection of host plant before entry to Thailand and survey around the risk area such as international border area are carried out. For export purposes, orc- hards with GAP certification and Good Manufacturing Practices (GMP) for packing house have been created. Integrated pest management and good agriculture practices are followed to achieve food security.

PNG country report was presented by Ramakrishna Akkinapally, NARI, PNG on 'Plant Health Research and Development in PNG'. He informed that scientific advice is provided on risk to consumers related to animals, plants and the environment, along with the whole food and feed chain. He explained that Pest Risk Assessment is done through pest categorisation, the possibility of entry, establishment, spread, impact and evaluation of risk reduction options. The challenges are strengthening capacity, infrastructure, research, extension, policy, etc. Recent initiatives undertaken were the training of quarantine and plant protection officers on Import Risk Analysis; update of pest lists; strengthening sanitary and phytosanitary measures in support of trade facilitation and effective export quarantine treatment i.e. high temperature forced air and pre-border biosecurity. Integrated Pest Management (IPM) practices in insect and disease management in the region were adopted.

Initiatives have been taken for biosecurity as well as for protection of country's economy, environment and people's health from insect pests and diseases. The priority areas identified are: phytosanitary regulatory services; need to develop a strategy for biosecurity in the region and identify general areas of priority to enhance trade facilitation; capacity-building in risk analysis of trans-boundary movement of LMOs into the region. Training of officers in Quarantine, Plant Protection and Environmental Services is required on risk analysis and general awareness about Genetically modified Organisms (GMOs)/ LMOs. It is also important to manage troublesome invasive weeds (Meremia, Balloon vine, African Tulip, etc) to enhance crop production in the region.

Samoa country report was presented by Kuini Tupou Tagai, Ministry of Agriculture and Fisheries (MAF), Samoa on the 'Plant health and development' and highlighted the issue of the pests as Taro is affected by root knot nematode (*Meloidogyne* sp.). To manage the nematode hot water treatment and high pressure washer is used by farmers. For management of Taro leaf blight, breeding for development of resistant variety is being carried out. For the management of *Banana bunchy top virus* (BBTV), chemical control of its vector aphids is adopted. Different management practices have been recommended for control of black leaf streak, coconut Rhinoceros beetle (*Oryctes rhinoceros*); *Brontispa longissimi* and B. *kirki* of avocado; B. *xanthodes* of breadfruit; diamondback moth and large cabbage moth. Availability of limited funds and resources; movement of research staff; imparting of training to new recruits; climate change; lack of leadership and management; lack of expertise in the handling of equipment; farmers behaviour, etc. are some of the challenges. However, initiatives such as encouraging the students to opt for agriculture in schools and university; establishment of plant health clinics; imparting training to farmers, organisation of awareness programs and legislation enforcement were undertaken. The priority areas are coconut Rhinoceros beetle, BBTV and Taro leaf blight and diseases of the high value crops.

SPC Fiji country report was presented by Siosiua Halavatau, Suva, Fiji- The Pacific Community – Land Resources Division (SPC-LRD), Fiji on 'Soil and Plant Health, Priority, Issues in the Pacific Islands'. He discussed the vital key issues to crop productivity. The flagship issue viz. loss of soil organic carbon is also associated with a cascade of secondary problems like less water availability, degradation, increasing insect pests and diseases, etc.

Challenges to successful implementation of soil and plant health research and extension activities are: individual and institutional capacity-building in soil, plant health research and capacity building in participatory research; strengthening of support services i.e. diagnostic laboratory services; biological support services for taxonomy/ identification, diagnostic research; communicating soil and plant health challenges; opportunities and advances to decision-makers at various levels and weak policy frameworks to support local food production and the exchange of improved plant genetic material. He also discussed about developing a strategy to unravel soil health problems and address plant health in the Pacific islands. He suggested soil analyses to establish soil health limitations such as chemical, physical and biological; field evaluation of soil; insect pests and diseases management technologies; evaluation of genetic resources for adaptation to soil conditions; insect pests and disease pressure and community involvement for scaling up and climate smart agriculture; soil doctor program etc.

He also presented case studies viz., *Case study* 1i.e. use of targeted compost in healthy home gardens on Atolls following 'Babai Food systems', 'Rain-fed Systems', 'Wicking based system' and 'Bucket drip irrigation System' and Case Study 2 i,e use of magic bean (*Mucuna pruriens*) on higher islands, the introduction of plant health clinic in Samoa and Fiji and availability of guiding Fact Sheets on Pacific Pest & Pathogen. The priority area is the promotion of an integrated approach for maximising production.

Technical session IV A : Knowledge Management, Outreach and Commercialization
Co-chairs: Dileepkumar Guntuku, SS Chahal
Rapporteur: Fai Collins

Dileepkumar Guntuku, Iowa State University, USA presented a paper on 'Digital Technologies in Support of Knowledge Management (KM), Outreach and Commercialisation'. He presented outline on Sustainable Development Goals (SDGs); Need of frontier agri technologies and digital technologies; Advances in Information and Communication Technology (ICTs)/ digital technologies; Emerging paradigm; Proposed APAARI KM-Platform.

He explained SDGs and role of ICT in the dissemination of agricultural technologies to stakeholders. He exhorted that hunger and malnutrition kill more people every year than AIDS, malaria, tuberculosis combined. Across the globe, close to 815 million (>1 in 10 people) go to bed with an empty stomach every night; malnutrition affects one in three people on the planet and food security, accessibility and affordability continue to pose critical challenges. He explained the development took place in ICT all over the world. He gave 'First Gen ICT4Ag Model' where radio, wireless sets, satellite TV, etc. were used. He also explained the use of internet and mobile phone in ICT for communication among the institutions, people especially the villagers through interactive voice response. Simultaneously Agri. tech. innovations took place with smart phones used with apps to implement various tasks related to agriculture and rural development viz. m-pesa, digital green, hellow tractor, airtel money, m kisan, kishan kerala, extension, etc. He also narrated different 'Advances in ICTs used in social media. These were Facebook wherein by July 31, 2018, Facebook boasted 1.86 billion monthly active users worldwide; 1.47 billion daily active users; 85.2 % daily active users are outside USA and Canada.

Similarly 'You Tube' wherein more than 1.57 billion unique users watch 5 billion videos every day; over 6 billion hours of video are watched each month on YouTube i.e. almost an hour for every person on Earth; more than 300 hours of video are being uploaded to 'YouTube' every minute. Likewise in 'Linked In' more than 467,000,000 are registered to interact among themselves. He explained the latest facilities being created for quick interactions viz. Highest Virtual Reality Resolution Facility in the World; Open Access Repository i.e. an interoperable open access institutional repository for knowledge product. He also dis- cussed Massive Open Online Courses (MOOCs) for capacity development, wherein more than 58 million users study 6850 courses all over 700 Universities. He exhorted that commercialisation with agri-preneurship is the need of hour, that provides aspiring or young innovators and entrepreneurs a platform with a variety of support services to help them develop, launch and scale up their products and services. In this Ag Knowledge Park, Agri-preneurship Labs, AgTech Innovation Labs, Agri-preneurship Knowledge Networks, etc. will be created. He highlighted emerging paradigm in ICT for Innovative Knowledge Sharing for reaching small holder farmers. He discussed the blueprint of the technology and strategic coalition of partners for knowledge acquisition and knowledge sharing; knowledge modelling i.e. knowledge organisations / validation packaging, etc.

He also proposed 'APAARI- KM Platform' to enable knowledge transfers among and across Asia-Pacific countries and providing Data Services, Information Services, Educational Services, etc. The partner countries can be benefitted for capacity development, information systems, ICT infrastructure, data system, etc.

SS Chahal, Ex Vice Chancellor, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur presented a paper on 'Coordination among Phytopathological Societies for Quality Improvement in India'. He explained that Professional Societies are the platform for professional growth and are the forum for the advancement of the disciplines. The performance and advancements in plant pathology are directly related to advancements in teaching and research in agricultural sciences. He cited that Indian Phytopathological Society was established in 1947, followed by Indian Society of Mycology and Plant Pathology, established at Jobner in 1971 and later shifted to Udaipur, Rajasthan. He also mentioned the establishment of Indian Society of Plant Pathologists at PAU, Ludhiana in 1984; Association of Plant Pathologists of India at Luck- now in 1984; Indian Virological Society at Hisar in 1985; Mycological Society of India at Chennai in 1973. He enlisted objectives and functions of the societies as to promoting cause of plant pathology; forum for interaction on phytopathological research, teaching and extension; dissemination of new knowledge through publication of journals, newsletters, books, bulletins and conference/ proceedings, etc.; organising scientific meetings, conferences, seminars, symposia, brainstorming meetings, etc.; facilitating liaison between plant pathologists, government and commercial organisations; affiliating /cooperating with other similar societies; examining present status of knowledge, identifying gaps and defining future course of action; preparing guidelines, vision documents and road maps to be proactive to face challenges in plant pathology. The Focus areas of these societies are Mycology, Fungal Pathology, Bacteriology, Virology, Phytoplasmology and Nematology.

He critically assessed the publication of papers related to different areas of Plant Pathology in Indian Phytopathology, Journal of Mycology and Plant Pathology and Plant Disease Research. He highlighted the role of different societies in human resource development which are listed as Develop modern teaching aids for bringing precision in delivery of instructions; Promote scientific interaction among fellow workers; Provide avenues for exhibiting talent as well as developing talent; Promote excellence through competition, incentives, awards and recognitions; Provide exposure and visits to other laboratories, institutions for preparing ground for new ideas and possibilities for solution of various problems. He also listed conferences / professional meetings being held by different societies are Zonal Meetings; Annual Meetings/ National Conferences; Special Seminars; Asian/ International Conferences; Brain Storming Sessions on special topics. He narrated efforts to develop cooperation between societies by formation of a federation i.e. Crop Protection Federation (CPF) with an aim 'to advance research, education, development including dissemination of information in various fields of crop protection' with the objectives of 'To share one platform for various activities related to crop protection; To facilitate flow of scientific information among stakeholders; To promote research publications of higher standards; To publish policy papers/reviews on important topics; To publish Newsletters for the benefit of members; To provide platform to address burning issues; To help in prioritising researchable issues in plant protection; To promote linkages of Agro-chemical companies, academia, corporates, Non-Governmental Organisations (NGOs), Non-Profit Organisations (NPOs), Donor agencies, etc.; To use synergy of various societies in resolving food security on global level; To interact with all the other organisations for furthering the cause of plant protection. He also mentioned that the CPF has organised brain storming session on "Need for National Strategies for Pest and Disease Management " and one-day seminar on "Scaling-up the Skills for Sustainability of Plant Health Management". He felt the need to consolidate the scattered activities of different societies on the Guiding Principles: Individuality of a Society to be maintained; Executive Committees of Member Societies to elect Executive Committee of the Federation and the Federation to develop cooperation among different societies.

RN Pandey, Anand Agriculture University, Anand presented a paper on 'Commercialization of *Trichoderma* spp. and other Bio-agents for Management of Stresses in Crops vis a vis for the Prosperity of Developing Nations'. He presented the plant disease scenario and the ill effects of excessive use of pesticides for management of diseases. Registered microbial bioagents viz. *Trichoderma harzianum*, T. *viride*, *Psuedomonas flourescens*, etc. are recommended for the management of plant diseases. They possess good characteristics, which qualify them as wonderful bioagents. More than 100 *Trichoderma* spp. have been reported, of which T. *harzianum*; T. *viride*; T. *asperellum* have been reported as endophytes. These are extensively studied for stress management, crop growth, enzymes production/ industrial usage, molecular biology, etc. They are cosmopolitan and abundant in all types of soils under stress, decompose organic matter and release micronutrients, NPK, etc., solubilize phosphate and micronutrients and make available to plants; produce growth hormones for growth of plants; manage biotic stresses i.e. control of plant pathogens due to competition for space, nutrition; siderophore production, mycoparasitism, antibiosis, cell wall degradation of fungal pathogens; produce multihydrolytic enzymes viz. cellulase, esterase, protease, chitinases, 1,6 ßGlucanases, 1,3 ß Glucanases, chitobiosidases; Associated antimicrobials in plant health i.e. induced systemic resistance, systemic acquired resistance i.e. production of alkyl pyrones; pentyl analogues; dermadin; isonitriles; polyketides; peptaibols; steroids diketo piperazines; management of abiotic stresses i.e. salinity, alkalinity, drought, allelopathic, etc. due root growth, nutritional uptake and protection against oxidative stress. These are presently marketed as bio-pesticides, biofertilizers, growth enhancers and stimulants of natural resistance. He presented the case studies for management of biotic and abiotic stresses in different crops viz. rice, maize, tomato, mustard, etc. and delivery systems for the best use of Trichoderma spp. in these crops such as seed treatment, nursery treatment, cutting and seedling root dip along with FYM, soil treatment, plant treatment, biopriming, multiple delivery systems i.e. through drip and microencapsulation.

He discussed the technologies generated by him and transferred to farmers viz. seed biopriming of mungbean, soybean and chickpea with T. *viride* for management of wilt and root rot and seed treatment with T. *viride* @ 10 g/kg seeds + soil application of enriched FYM (100 g T. viride/ kg FYM) @ 100 g/m2 of soil/ furrow for the management of wilt and root rot of chickpea. He emphasised to develop Consortium of *Trichoderma* spp. and bacterium, *Psuedomonas fluorescens* and enrichment of FYM and other organic manures viz. mustard cake, castor cake, etc. for mass multiplication of *Trichoderma* spp. He presented the effect of biopriming of T. viride on root and shoot growth of chickpea and control of collar rot (*Sclerotium rolfsii*). He presented mass production of *Trichoderma* spp. utilizing agricultural waste as well as utilizing organic matter. He explained the procedures for commercialization of *Trichoderma* Spp. viz. isolation of native efficient strains from the natural ecosystem; standardization of solid and liquid state mass production; developing formulations for better shelflife; standardization of different delivery systems for better efficiency; compatibility with different agro-chemicals to use them simultaneously, if required; registration etc.

Discussed the success story of commercialization of T. *viride* for the use of farmers achieved under 'Rashtriya Krishi Vikash Project' sponsored by the Government of Gujarat and Government of India. Discussed economics of production, sale and profit of commercialization of the technology which is profitable and self- sustained. Therefore, it can be adopted wellby the youth and farmers to become entrepreneurs for the production of *Trichoderma* spp. The largest distribution of '*Trichoderma* bioproducts' is in Asia, succeeded by Europe, South- Central America and North America. This is a Sun rise sector and has enormous opportunities to create jobs for farmers, youth, etc. and enhance socio- economic conditions, thereby solving the unemployment problems among youth and make the country prosperous.

MP Thakur, Indira Gandhi Krishi Vishwavidyalaya (IGKV), India presented a paper on the 'Views on Reaching the Farmers in an Innovative Way'. He informed that like scientific academic societies, an effort was made at IGKV, Raipur to award *Farmers Fellow Award* to the selected farmers of the state based on their innovative ideas identified by the high level committee by inviting applications not only to recognise the farmers but to disseminate their ideas/technologies/best practices developed by them among other fellow farmers. Based on this, the Government of Chhattisgadh instituted new award entitled "*Kisan Vistar Protsahan Purustkar*" of Rs.1.00 lakh for those transferring new technology to 100 or more farmers; Rs.50,000/- to those transferring new technology to 50 or more farmers and Rs.31,000/- to those transferring new technology to 30 or more farmers in order to disseminate and adopt new technology. For actively involving farmers in the research programmes, IGKV started a new *Farmers Participatory Research Project* in which the farmers were Co-Investigators and have equal weight age like the scientist in the development of the technology. The experimentation was done in the farmer's field only, to fully involve him, his idea and his view point. He said, this was how, farmers were involved and effectively communicated with farmers in the development, refinement, spread and adoption of the new technology.

Technical Session IV B - Poster Presentations:
(Sessions for Highlights of Posters
Co-chairs: SM Paul Khurana, MB Chetti
Rapporteur: Kajal K Biswas

AA Yadav, Shivaji University, India presented a paper on 'Effect of Sodium Chloride Salinity and Distillery Effluent on Mineral Nutrition in Dirt Weed'. Findings revealed that sodium got accumulated in the *Chenopodium album* L. (Dirt weed) due to increasing NaCl salinity. Sodium content in *C. album* leaves has increased up to 10 Electrical Conductivity and potassium content decreased up to 8 Electrical Conductivity of NaCl concentrations. There was also an adverse effect of salinity on calcium uptake and distribution in the 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 a lower concentration, however, declined at higher concentration. Mg++ content in *C. album* leaves declined with increasing concentration of distillery effluent. Iron was accumulated in theleaves except in a 40% concentration of distillery effluent.

LM Khade, Shivaji University, India presented a paper on 'Ecofriendly Management of Linseed Blight caused by Carbendazim Resistant Isolates of *Alternaria lini Dey'*. The experimental results revealed minimum inhibitory concentrations (MICs) of carbendazim varied among 15 isolates of A. lini causing leaf blight of *Linum usitatissimum* L. as determined by Poisoned food technique. Among these 15 isolates, isolate AL-9 was sensitive tolerating 3% carbendazim while AL-5 was resistant and its MIC was 22%. Therefore, to manage such carbendazim resistance in A. *lini*, three *Trichoderma* spp. were screened against carbendazim sensitive and resistant isolates of A. lini by dual culture technique for their biocontrol potential. Among the three species of *Trichoderma*, T. *harzianum* showed maximum antagonistic potential (82.22%) against a 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%). **Shital B Koparde, Shivaji University, India** presented a paper on 'Management of Linseed Blight by Green Silver Nanoparticles Synthesised from *Simarouba glauca* for Development of Organic Culture'. In the present work an attempt was made to synthesise silver nanoparticles by using medicinal plant *S. glauca*. and assessment of antifungal potential against *Alternaria lini*. Synthesised nanoparticles were spherical. The size ranged between 30-50nm for nanoparticles synthe- sised using leaf sample and 50-60nm for nanoparticles synthesised from bark sample. Silver nanoparticles synthesised from leaves and bark extract of *S. glauca* have the potential to inhibit the growth of carbendazim resistant strain A. *lini*, causing linseed blight. Silver nanoparticles synthesised from leaves showed higher inhibitory activity than nanoparticles synthesised from bark sample. Thus the silver nanoparticles synthesised from *S. glauca* was useful in managing the pathogen and maintaining the crop yield. This will reduce the resi- dues of fungicides and also useful in the development of chemical-free organic farming. **Sushma Sharma, Eternal University, India** presented a paper on 'Man-

agement of Late Blight of Tomato Disease in Sirmour Areas of Himachal Pradesh'. She presented that fungal diseases are of most economic importance and are responsible for huge losses to the tomato growers. Among them, *Phytophthora* is a serious threat to tomato production. An extensive 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 growth medium and the isolated pathogen associated with the disease was identified based on 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 varieties showed resistant reaction while Punjab Verkha Vihar 2R exhibited highly susceptible reaction. Disease management with chemicals, biocontrol agents and bioformulations was carried out individually. The combination of Metalaxayl + Mancozeb among various fungicides was effec- tive and among botanicals, cow urine was the most effective in inhibiting the growth of the pathogen.

Monika Jangir, Indian Institute of Technology (IIT), Delhi, India presented a paper on the 'Efficacy Evaluation of *Bacillus subtilis* and *Trichoderma harzianum* in Suppression of *Fusarium* wilt in *Solanum lycopersicum*'. The present work was conducted to investigate the antagonistic efficacy of B. *subtilis* and T. *harzianum* against *Fusarium* wilt in S. *lycopersicum*, individually as well as in combination, and compare its efficacy with the current practice of amendment with chemical control. F. *oxysporum* f. sp. *lycopersici* is soil-borne fungal pathogen 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 *invitro* 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 i*n-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. It suggests that B. *subtilis* and T. *harzianum* consortium could serve better in the mitigation of wilt and plant growth enhancement of S. *lycopersicum* as compared to single inoculant.

Parinda Barua, Assam Agricultural University, India presented a paper on 'Bacteriophages of *Pseudomonas savastanoi* pv. *savastanoi*, its Isolation and Characterisation'. Bacteriophages are considered as potential biocontrol agents due to their attributes. The present study was undertaken to isolate and characterise the bacteriophages infecting P. *savastanoi* pv. *savastanoi*, the causal agent of 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 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 characterisation, telectron microscopy was carried out and observation of phages under Transmission Electron Microscope (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 an affinity to the phage family: Siphoviridae under the Order: Caudovirales. Molecular characterisation of the phages was carried out by next generation sequencing. 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% with already identified phage genomes indicating the presence of some novel bacteriophages that are yet to be characterised.

Faheem Ahamad, Aligarh Muslim University, India presented a paper on 'Effects of Some Rhizosphere Biocontrol Agents on Rice Root-knot Nematode, *Meloidogyne graminicola'*. 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, M. *graminicola* 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 12, six most efficient isolates were selected to ascertain their effectiveness under pot conditions (Pi = 1000 J2 /kg soil). The BCAs (2-3 × 106 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 a 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 the 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 P. *lilacinus* AMUPL-1 (20-34%), followed by T. *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 the 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 colonised 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%.

Ranima Mishra, Assam Agricultural University, Jorhat, India presented a paper on the 'Sero-diagnostics through Polyclonal Antisera Production and Molecular Characterisation of Potato virus Y Isolate from Jorhat District of Assam'. She informed that potato production is affected by various viral diseases that reduce yield quality and quantity. Amongst all the viruses, *Potato virus Y* (PVY) is recognised 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 a standard procedure to obtain purified viral protein. Purified viral protein (antigen) was used for raising polyclonal antibodies in rabbit through immunisations 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 six 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 antirabbit 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 titers 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 the presence of the virus in the tested samples, total RNA was isolated from infected potato sample from field and standardisation for reverse-transcription 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.

CH Nusrath Beegum, Kerala Agricultural University, India presented a paper on 'Characterisation and i*n vitro* Management of *Choanephora cucurbitarum* on Cabbage and Cauliflower in Kerala, India'. Characterisation of C. *cucurbitarum* causing leaf blight and head rot in cabbage and curd rot in cauliflower was done using morphological and cultural characters and was confirmed by molecular methods. The survey conducted at four districts of Kerala showed a maximum disease severity of 40.9% leaf blight and head rot in cabbage, 12.4% curd rot in cauliflower from Chullikkara area of Kasaragod district, Kerala state in India. 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 32.80-74.91 µm diameter. Sporangiospores were found as brown colour, elliptical to ovoid in shape and 12.68-18.38 µm x 6.48-7.99 µm size. Among fungicides tested tebuconzole 5EC (Fo- licure) (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% concentrations. T. *viride* was most effective against C. *cucurbitarum* with 74% inhibition of mycelial growth. P. *fluorescens* inhibited 65% mycelial growth of the pathogen whereas B. *subtilis* restricted the mycelial growth up to 47.5%.

Surbhi Gupta, Manav Rachna International Institute of Research and Studies (MRIIRS), India presented a paper on 'Biological control of *Alternaria brassicae*, the Causal Agent of Brassica Leaf Spot Disease, using Rhizospheric Bacteria'. She informed that Indian mustard (*Brassica juncea Coss. & Czern*) is an important oilseed crop in India. *Alternaria* leaf spot, also known as *Alternaria* blight of mustard is incited by fungus *Alternaria brassicae*, which causes a yield loss of up to 70%. A total of 35 bacterial isolates were isolated from the rhizosphere of mustard, tomato and brinjal and they were screened for their antagonistic activity against A. *brassicae* under in vitro conditions. 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 Indole-3-acetic acid (IAA) production, Hydrogen Cyanide (HCN) production and ammonia production under *in vitro* conditions.

Maximum IAA production (43.75%) was shown by isolate BM3 and BM12 with a colour change from white to pink; high ammonia production (58.25%) was observed in isolates BM21, BM3 and BM9 with a colour 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 the 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.

Jutimala Phookan, Assam Agricultural University, India presented a paper on 'Impact of Climate Variability vis-á-vis Yield Loss on the Occurrence of Sesamum Phyllody Disease in Jorhat District of Assam, India'. Sesamum phyllody is caused by a phytoplasma and spread by leafhopper vector Hishimonus phycitis (Dist.). Effects of meteorological parameters on the phyllody development and assessment of yield loss was carried out 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 the summer and kharif season. The highest incidence of 17.60% in summer and 22.16% in kharif season in the crops sown on 15th April 2017 and 1st August 2017, respectively, was observed. Polymerase Chain Reaction (PCR) assays with universal primers P1/P6 confirmed the presence of phytoplasma in the plant samples as well as in the vector H. *phycitis*.

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 highest reduction in number of pods per plant and number of seeds per pod was observed as 79.39% and 56.95%, respectively, during the summer season, while in the kharif season, reduction for the above mentioned para- meters were 80.33% and 61.25%, respectively. No significant difference was observed for 1000 seed weight among the different sowing dates for both the seasons.

NM Praveen, Kerala Agricultural University, India presented a paper on 'First record of *Myrothecium roridum* Causing Leaf Spot Disease in Gerbera'. Gerbera is cultivated throughout the world for cut flower as well as for ornamental potted plants. 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 the hydroponic system. Three month old plants were affected with the disease which was observed only during November-December with disease incidence and severity of 53.1 and 9.1%, respectively. The disease severity increased at temperature of 23.8-31.9°C,

the relative humidity of 65-75% and rainfall of 88.3-151.2 mm. However, the disease was less prominent especially during summer and monsoon season. The pathogen was isolated and pathogenicity was proved by Mycelial Bit Inoculation Method (MBIM) and Mycelial Droplet Inoculation Technique (MDIT). Black water-soaked lesions ap- peared on upper surface of leaf lamina which later enlarged to form large blighted areas that ap- peared 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 werehyaline, one-celled, rod-shaped with rounded ends and measured 5 to 10.74 × 2.0 µm and identified as *Myrothecium roridum* (ID No. 7948.15).This is the first report of *M. roridum* causing leaf blight in gerbera.

TB Manjunatha Reddy, University of Horticultural Sciences, India presented a paper on 'Bioefficacy of New Fungicide Molecules against Early Blight and *Septoria* Leaf Spot Diseases of Tomato'. Early blight (*Alternaria solani*) and *Septoria* leaf spot (*Septoria lycopersici*) are the most economically important and destructive foliar diseases of tomato and have become major constraints for tomato production. Farmers depend upon fungicides to protect the crop as commercially cultivated hybrids/varieties are susceptible to these diseases. Among the various fungicides tested, the combi product Fluxapyroxad 250 g/l + Pyraclostrobin 250 g/l 500 SC @ 0.06% was the most effective registering least Percent Disease Incidence (PDI) of 4.00 against early blight followed by the same fungicide at doses of 0.05 and 0.04% with PDI of 6.67 and 9.33, respectively, as against untreated control (30.67).

Similarly, the same fungicides gave maximum disease control (5.33 PDI) followed by the same fungicide @ 0.05% (8.00 PDI) against *Septoria* leaf spot as against control (30.67 PDI). The same product @ 0.04% (9.33 PDI) and @ 0.03% (10.67 PDI) was found effective against *Septoria* leaf spot as compared to fungicides Pyraclostrobin @ 0.1% (12.00 PDI), Fluxapyroxad @ 0.04% (13.33) when tested alone . 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 doses of 0.05, 0.04 and 0.03% with yield of 31.43, 27.50 and 26.03 t/ha, respectively, as against untreated control (22.97 t/ha).

Pankaj Kumar, Chaudhary Charan Singh Haryana Agricultural University, India presented a paper on 'Revealing the Population Structure of *Rhizoctonia solani* AG-1 IA Isolates Causing Sheath Blight of Rice in Different Agro-climatic Zones of Haryana, India'. Sheath blight of rice caused by R. solani Kuhn has emerged as one of the major diseases causing substantial quantitative and qualitative losses. Keeping that in view, the relatedness of 66 R. *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 the source of origin and geographical location with the morphological, pathogenic and genetic composition of the fungal isolates. The isolates of R. *solani* varied considerably concerning cultural and morphological characters viz. mycelial growth rate, number of sclerotia formed, mycelial width, the 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, 11 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 analysed 17 R. solani isolates characterised into two groups which correlated with the morphological and pathogenic characters.

Shankar Hemanta Gogoi, Assam Agricultural University, India presented a paper on 'Association of Leafhopper Vectors and Alternate Hosts in Transmitting Sesamum Phyllody Phytoplasma and its Molecular Characterisation in Assam, India'. Sesamum phyllody caused by phytoplasma is a serious disease. Sesamum phyllody symptoms were observed in the farmers field. 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 identified in the field. Transmission studies were done by O. *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*. Four alternate weed species were also identified in the field and indexed through PCR. There was no effect on germination of seeds collected from infected plants.

Sequencing was done in two 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 which 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.

Devendra Singh Negi, State Training and Research Centre for Organic Farming, India presented a paper on 'Eco-friendly Management of Rice Blast Disease caused by *Pyricularia oryzae* in Field Condition at Uttarakhand, India'. Rice blast (P. oryzae) is one of the most important diseases of rice (Oryza sativa L.). Field studies were conducted 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 using Dehraduni basmati rice (Type-3) in randomised block design with three replications. Strains of T. *harzianum* and P. *fluorescens* were obtained from hill campus, Ranichauri, GB Pant University of Agriculture and Technology, Pantnagar, India. Both bioagents were used alone and in the consortium, 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 the 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. P. fluorescens recorded 25.71 PDI at 45 DAT and 16.19 PDI at 60 DAT over control. C. *longa* (1.5% and 1.0%) foliar sprays gave 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 control (15.0 q/ha). Overall, grain yield in the treatments was higher than control.

CH Nusrath Beegum, Kerala Agricultural University, India presented a paper on 'Physiological Characterisation and Standardisation of Culture Medium for *Ophiocordyceps neovolkiana* (Kobayasi) from Kerala, India'. The mysterious fungus *Cordyceps* sp. recommended by Chinese medical 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. Molecular and physiological characterisation and standardisation of culture medium for *Ophiocordyceps* sp. was done. The molecular characterisation by ITS sequencing of the fungus showed homology with O. *neovolkiana* (Kobayasi) with NCBI No. MH 668282 and culture deposit No. NFCCI 4331. Among media, Yeast potato dextrose agar (YPDA) was found best followed by potato dextrose agar (PDA). The optimum temperature of 30ºC, optimum pH of 7.0, fructose as best source of carbon, yeast extract as 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. By combining all the optimum conditions a new medium was standardised and named as Yeast Extract Potato Fructose Agar (YEPFA) for the O. *neovolkiana*, with the composition of 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 a litre of distilled water which supported maximum growth. Sorghum grains were the best substrate for growth followed by rice and wheat grains. 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).

Subrata Bora, Assam Agricultural University, India presented a paper on 'Identification, Detection and Molecular Characterisation of Citrus Greening Disease in Assam using Real-time PCR'. Citrus Greening Disease (CGD), 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% yield loss around the globe. Khasi mandarin (*Citrus reticulata*) is an important citrus of Assam in India. A field survey of Khasi mandarin showing the disease symptoms of small and upright leaves, chlorotic mottling in citrus growing areas of Tinsukia, Jorhat and Golaghat districts of Assam was conducted. DNA extracted from the collected leaf samples using CTAB method, then followed by PCR analysis using CGD primer pair A2 (Forward 5' TATAAAGGTTG ACCT TT CG AGTTT 3') and J5 (Reverse 5' ACAAAAGCAGAAAATAGCCACGAACAA 3') for amplification.

All the samples yielded a 700 base pair 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% similarities with other isolates.

Prithviraj Pegu, Assam Agricultural University, India presented a paper on 'Application of Seed Priming Techniques for Offseason (Boro) Healthy Seed Production and Disease Control of Rice in Assam'. Assam is a major rice growing states of India of which about 0.5 m ha of Sali rice area is affected by the flood. Ranjit (IET-12554) is the popular rice variety showing 66% increase in productivity in Assam. Off-season seed production of paddy will help the farmers in meeting their requirement of quality seed during flood and 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 enough water for radicle protrusion and suspends the seeds in the lag phase. Seed priming was done using the seeds of Ranjit (IET-12554), Bishnuprasad (control) and Jyotiprasad (control). The treatments consisted of Control, Chemical priming with salicylic acid and melatonin, Osmopriming with PEG6000 solution, Hormonal priming with GA3, Nanopriming with ZnO nanoparticles and Biopriming with bioagent T. *harzianum* and P. *fluorescens* in three replications.

After priming the seeds, effect of different priming methods on field emergence and subsequent morphophenological and yield characters in boro season was tested, followed by seed quality parameters in offseason planting. The results revealed that of the three priming techniques used in this study viz., nanopriming, biopriming and hormonal priming were very effective as it showed a positive effect on seed performance along with more than 85% germination under cold stress.

Partha Pratim Baruah, Assam Agricultural University, India presented a paper on 'Food Security vs Plant Diseases: An Indian Perspective'. 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 in post -independence have emphasised on reducing poverty, hunger and food insecurity. The component of food security includes food availability, physical and economic access to food, and food utilisation like nutritive value, food safety, as has been recently reviewed. Plant protection against plant pests, have an obvious role to play in balancing the growing demand and supply of food quality and quantity. Roughly, direct yield losses caused by pathogens range between 10 to 12.5% of global agricultural productivity, while in India it accounts for 15 to 30% loss in production.

Thus, losses caused by plant disease directly affect the components of food security or indirectly through the fabrics of trade, policies and societies. Crop losses 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.

Shaily Javeria, Amity University, India presented a paper on 'Antagonistic and Plant Growth Promotion activity of *Trichoderma* isolates against *Fusarium oxysporium* f. sp. *lentis*'. The biocontrol activities of 12 isolates of *Trichoderma* spp. were tested against 30 isolates of *Fusarium oxysporum* using dual culture, as well as volatile and non-volatile techniques. Maximum percent inhibition of radial growth was found in T. *harzianum* (82.4%), T. *harzianum* (ThL-4) (80.6%) and T. *asperellum* (TaL-2) (80.0%). 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 with 65% (v/v) concentration. *Trichoderma* spp. was observed to produce a coiling structure of *Trichoderma* mycelium over *Fusarium* mycelium for controlling the growth. The selected isolates (5593, ThL-4 and TaL-2) of *Trichoderma* were found effective in seed germination, in- creased 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.

FD Yadav, KS Saket PG College, India presented a paper on 'Eco-friendly Approaches to Alleviate the Disease in Seedlings caused by *Pythium* sp., in Faizabad District of Uttar Pradesh, India'. 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% under nursery condition. Interestingly, 130 µm polythene thickness was better than 80 µm in reducing the total fungal pathogen population and increasing seedling stands. Of the tested phytoextracts, *Ocimum sanctum* extract was found to highly inhibit *Pythium* sp. 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 T. *harzianum* @ 4g/kg seed, followed by solarisation + seed treatment with carbendazim, Thiram, and Dithane M-45. The mortality rec- orded in solarised plot was 31.85%, whereas it was 46.88% in the control. The minimum preemergence mortality was observed in SS + ST with T. *harzianum* (19.24%), followed by SS + ST with Carbendazim and SS + ST with Thiram showing 20.06% and 22.04%, respectively.

AS Salunkhe, College of Agricultural Biotechnology, India presented a paper on 'Antifungal Attributes of Phosphate Solubilising *Burkholderia* sp. VIMP04 (JQ867373) against Soil-borne Fungal Pathogens of Sugarcane'. The objective of the present study was to investigate the anti- fungal features of *Burkholderia* sp. VIMP04 (JQ867373), a phosphate solubilizing isolate from sugar beet rhizosphere was tested by 'Dual culture' and 'Agar well diffusion methods' against soil-borne pathogens *Ceratocystis paradoxa* and *Alternaria alternata* causing pineapple and leaf spot diseases of sugarcane, respectively. Present bacterial culture solubilised tricalcium phosphate and rock phosphate and produced 71.8% and 32.4% soluble phosphorus. Culture filtrate and ethyl acetate extract obtained from the culture supernatant of *Burkholderia* sp. VIMP04 (JQ867373) showed prominent antifungal activity.

HPLC analysis confirmed the 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 antifungal fractions contained about nine 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. The culture under study can be used as biocontrol agent.

Akanksha Tyagi, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India presented a paper on 'Biodiversity Conservation and Phylogenetic Systematics of Twenty Aspergillus Species of India'. Aspergillus is known as plant and human pathogen, as post-harvest patho- gen of fruits and vegetables and also as potential 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 into 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. Molecular characterisation based on ITS was performed for reliable identi- fication and ß-tub for their phylogenetic relationship. The ß-tub gene has 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 β-tub gene sequences of all the species studied have been deposited in the GenBank.

Rishu Sharma, Bidhan Chandra Krishi Viswavidyalaya, India presented a paper on 'Identification of Wild Mushroom from West Bengal using Molecular Markers'.*Pleurotus* spp. constitute one of the edible mushrooms, commonly known as Oyster mushroom. There are confusions in classifying *Pleurotus* isolates using only morphological characters due to the large influence exerted by environmental factors.

Population structure analysis using morphocultural traits of an individual is not a reliable procedure, the 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, Solan, Himachal Pradesh and one was wild from Bankura district of West Bengal. PCR amplification of genomic DNA 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 program. The analysis showed a homology of 94% to *Xylaria* spp. which is pointing to a different observation in comparison to our morphological studies. Morphological characteristics showed it could be a *Pleurotus* sp. which is 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 wild mushrooms.

V Ambethgar, Horticultural College and Research Institute for Women, India presented a paper on 'Impact of Soil-applied Mineral Nutrients (NPK Fertilisers) 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 North-eastern Tamil Nadu, India'. Cashewnut (*Anacardium occidentale* Linn.), a high-value commercial crop of India, is largely grown in marginal soils of dryland belts. The realised nut yields are usually considerably lower than potential yield, largely due to the depletion of available soil nutrients coupled with the vulnerability of stressed plants to insect pests and disease manifestations. Reinforcing soil fertility through supplementation of mineral nutrients may help to mitigate insect pests and disease manifestation induced under stress caused by a nutrient loss in soil. The studies were conducted on the influence of nine different NPK fertiliser 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 27 treatment combinations on the incidence of TMB, *Helopeltis antonii* Signoret (Heteroptera: Miridae) and its induced infections of foliar diseases on five years old VRI-2 clonal cashew orchard. Results revealed that soil application of nitrogen higher than the recommended doses sharply increased the population of H. antonii and 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. Increased doses of phosphorus and potassium applied in the 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*, whereas the higher yield resulting from combination of NPK nutrients might be due to increased plant vigour, which resulted in withstanding capacity of the plant to tolerate pests without affecting the yield of nuts.

B Hanumanthe Gowda, ICAR-Krishi Vignana Kendra (Indian Institute of Horticultural Research), India presented a paper on 'Studies on IPM Technology Demonstration for Sustainable and Safe Mango Production in Tumkur district of Karnataka'. Increased environmental awareness has led to the need for sustainable agricultural production systems. IPM becomes the 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, using Indian Institute of Horticultural Research (IIHR) developed IPM technology for control of both insect pests and diseases in mango. IPM technology i.e. spraying of botanical pesticides, use of fruit fly traps and hot water treatment etc. was tested. Results revealed that the incidence of both insect pests and diseases significantly varied. Powdery mildew incidence ranged from 6.68-8.95% in demonstrated orchard compared to 28.78% in control orchard. Anthracnose severity on fruits decreased to an extent of 58.83% demo orchard over control. Demo orchard recorded the decreased fruit fly infestation of 8.66% as against 38.13% in control orchard due to 100% adaption of IPM practices.

An average yield of quality fruits of 54.60% was observed in demonstration orchards. On two years average basis, the technology gap of 20 demonstrations was observed as 2.38 t/ha. The higher additional returns and effective gain obtained under demonstrations could be due to the potentiality of the IPM technology in controlling both the insect pests and diseases. Farmers were also extremely satisfied as the IPM technology facilitated in getting more demand of their produce due to fruit quality particularly size, texture, shape, uniform ripening and assured chemical-free production.

V Prakasam, ICAR-Indian Institute of Rice Research (IIRR), India presented a paper on 'Significance of Rice Sheath Blight in India and its Management through Host Plant Resistance/Tolerance'. Sheath blight (*Rhizoctonia solani*) is the major constraint for rice production as it can cause yield loss up to 70-80%. 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. The 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, EastCoast, WestCoast and parts of central plains in India. About 120 Sheath blight pathogen isolates from across India 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 Coordinated Research 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 the artificial conditions 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 the tolerant check. 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-Polymerase Chain Reaction (qRT-PCR).

Results showed that the expression rate of nine 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 Recombinant Inbred Line (RIL) population for characterizing sheath blight resistance. The RIL population of ISM/Wazuhopehk (F8 stage) was artificially screened. Out of 330 F7 and F8 lines, seven lines were identified with a good level of resistance for two seasons.

KD Thakur, College of Agriculture, Dr Panjabrao Deshmukh Krishi Vidyapeeth, India presented a paper on'Seed-borne Fungi associated with Soybean'. Soybean (*Glycine max*) crop is infected by seed and soil-borne fungal pathogens. 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. Results revealed the presence of A. *niger*, *A. flavus, Fusarium oxysporum, Colletotrichum dematium, Rhizoctonia bataticola, Curvularia lunata, Alternaria alternata* and *Rhizopus stolonifer* in all seeds. However, standard blotter paper method was found most efficient in recording more number of fungal colonies.

SB Bramhankar, College of Agriculture, Dr Panjabrao Deshmukh Krishi Vidyapeeth, India presented a paper on 'Evaluation of Fungicides and Botanicals against Major Seed-borne Fungi of Groundnut'. *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, A. 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, Captan 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 mycelial growth of all pathogens. These fungicides inhibited 100% growth of A. *flavus*, A. *niger*, F. *oxysporum*, R. *bataticola* and S. *rolfsii*. *Allium sativum* extract showed 100% growth inhibition in all these pathogens.

L Manjunatha, ICAR-Indian Institute of Pulses Research, India presented a paper on'Prevalence and Distribution of *Ascochyta rabiei* in India and Identification of Resistance Sources'. Ascochyta blight (*Ascochyta rabiei* (Pass.) Labr) is a major constraint for chickpea production in India and worldwide, causing 50-100% loss under severe infection. During 2016-17, only 4-10% incidence was observed with negligible severity on cultivars L-550, GPF 2, GNG series and local desi types in Punjab, Jammu and Uttarakhand states of Northern India. During the year 2017-18, 2% (PBG 7) to 100% (L-550) incidence was observed at Ludhiana and up to 50% at Gurdaspur as compared to < 2% in other districts of Punjab. The major cultivars cultivated in Punjab are PBG 5, PBG 7 and GPF 2 which are mainly tolerant. In Samba region of Jammu & Kashmir state observed only 2-3% incidence with less or negligible disease severity. No incidence of the disease was observed at Sri Ganganagar district of Rajasthan in both the years. In Udham Singh Nagar and Nainital districts of Uttarakhand observed 2-5% in the chickpea.

The screening was done to identify the resistance sources against A. *rabiei*. A total of 380 chickpea cultivars/lines and germplasm collected from ICAR- National Bureau of Plant Genetic Resources (NBPGR) were screened under controlled environmental facility (CEF) where, leaf wetness up to 72 hours after inoculation and 70-80% relative humidity were maintained during the subsequent 1days. Among these genotypes viz. 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 resistant. The information might be useful for farmers to grow resistant cultivars as a precautionary measure to prevent the loss caused by the disease and resistant sources will be useful developing resistant cultivars.

Technical session V: Eco-friendly Approaches for Soil and Plant Health Management
Co-chairs: CD Mayee, Pattara Opadith
Rapporteur: Dilip K Ghosh

AN Mukhopadhyay, Former Vice Chancellor, Assam Agricultural University, India presented a paper on 'Plant Disease Management with Ecofriendly Biopesticides'. He put forward that despite the success of the 'green revolution,' the battle to ensure food and nutritional security for hundreds of millions of miserably poor people is far from won. He put his concern that ever growing populations, changing demographics and inadequate poverty intervention programs have eroded many of the gains of the 'green revolution', in India. We are losing nearly Rs.2,25,000 crores worth agricultural produce due to pests. With the present rate of growth of the population we have to double our food production by 2030. According to WHO, FAO and United National Environment Programme (UNEP) reports (2004, 2008), between 1 to 5 million cases of pesticide poisoning occur each year resulting in the death of 1 to 3 lakh people. It is clear that the "21st century" is going to be a century of the environment in which literally every new technology will have to meet environmental concerns. *Trichoderma* spp. are unique biopesticide of its kind for plant disease management in the 21st century. He discussed the path-breaking facts about *Trichoderma*. During the last decade, species of *Trichoderma* have emerged as most powerful bioprotectants for the management of a wide variety of plant diseases. This is true in the context of the fact that there is considerable public pressure and pressure from environmental scientists to reduce the 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 bio-pesticides have been proved successful in a large number of fields, vegetable, fruit and flowering crops for the management of diseases. Because of its ecofriendly nature and low cost when compared with chemical protectants, the technology has been widely adopted 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. The root-fungus association also stimulate plant defensive mechanisms.

Trichoderma added directly to rhizosphere or as seed treatment protects the plant against numerous classes of pathogens, e.g. those that produce aerial infections, including fungal, bacterial, nematodes and viral pathogens. This reveals the 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.

Mary Atieno, International Center for Tropical Agriculture (CIAT)-Asia, Vietnam presented a paper on the 'Soils & Agroecology: Common Microbial Biotechnology Platform'. She presented CIAT research areas as: Agrobiodiversity in the bean, tropical forages, cassava, rice and genetic resources; Agroecosystems & Landscapes for landscapes restoration, Soil fertility & health, ecosystem services; *Decision & Policy analysis* in the areas of climate change for sustainable food systems, digital agriculture. She also discussed CIAT Asia research themes such as adding value to cassava improved forage options for more productive livestock production, climate- resilient agriculture, strategic public-private investment priorities in high-value agricultural commodities etc. She gave details about the Common Microbial Biotechnology Platform(CMBP) for harnessing microbial biotech tools for sustainable agricultural systems and landscapes. The Current partners of CMBP are CIAT, the French Agricultural Research Center for International Development (CIRAD), Agricultural Genetics Institute (Vietnam), Chinese Academy of

Tropical Agricultural Sciences (CATAS), Deakin University (Australia) etc. She discussed the relevance of using microbial biotechnologies in tropical agriculture as there is the need for restoring degraded soils by enhancement of soil biodiversity for soil health, promotion of agro-ecology with no or low tillage, low or nil inputs agriculture, intercropping legumes-crops, agroforestry, etc. and utilisation of beneficial microbial products. She explained that there are three programmatic areas of CMBP viz. quality control, formulation of rhizobial and mycorrhizal inoculants and developing biotechnology methodologies for assessing the role of microorganisms in the sustainability of cultivated soils. She gave a critical account of research, training and publication at CMBP. She gave details about capacity-building for inter-cropping legumes in Vietnam and Myanmar and availability of Crawford fund for agronomy and soil health, legumes and rhizobia, etc. She also informed about CATAS-CIAT joint laboratory in tropical agriculture with the research scope in the areas of tropical agricultural commodities and systems; genetic resources, crop health and integrated farming systems and advanced scientific methods and tools, etc. She also gave details on the Asia forage legumes platform.

She summed up the talk that there is a need for strong will to pursue, strengthen and sustain collaborations at the regional level; setting up of common research tools/laboratory facilities/regional platform for doing relevant research; capacity-building for researchers, academics, students and hoped for emergence of new collaborative programmes in the area of climate resilience and ecosystem services.

Srinivasan Ramasamy, World Vegetable Centre, Taiwan presented a paper on 'Eco-friendly Approaches for Soil and Plant Health Management in Tropical Vegetable Production'. The presentation was made about the Association of International Research and Development Centers for Agriculture (AIRCA) which is an independent consortium and World Vegetable Center (WVC) is part of Consortium. He gave an overview about flagship programme of WVC as vegetable diversity and improvement, healthy diets, safe and sustainable value chains and enabling impacts. It specifically focuses on technological innovations, institutional innovations and transformative platforms. He presented the scenario of global nutrients (N+P2O5+K2O) consumption, world and regional growth in fertiliser demand from 2014 to 2018, fertiliser use in Asia and vegetable production area in Asia, vegetable production systems in Asia, soil health and plant nutrition research areas at WVC. He put the emphasis on efficient use of major nutrients and informed that 619 improved cultivars were released in 69 countries since 1978 by WVC.

He informed the audience about the indiscriminate use of pesticides in vegetable crops due to plethora of pests and these are high-value crops. Therefore, for pests management the priority areas are host plant resistance, use of insect pheromones, use of biological control agents, biopesticides, integrated pest management (IPM), biopesticide based IPM especially for yard-long bean in Cambodia and bridging the gap in GAP. He discussed technological innovations that should be available, accessible and affordable. In case of institutional innovations, he opined that it should be enabling policy environment as for biopesticide legislation in Bangladesh, harmonisation of regulatory processes on bio-control agents in Southeast Asia. There is need for public-private partnerships and consumer-driven technology adoption (bottom-up approach).

Rajan Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India presented a paper on 'Disease Management through Host Plant Resistance'. He focused on blast and downy mildew (DM) of pearl millet. He emphasised that for disease management through horizontal plant resistance, sound knowledge of biology and epidemiology of the disease, availability of pure culture of the pathogen, effective inoculation technique, an appropriate disease rating scale, availability of large variable germplasm, adequate laboratory, greenhouse and field facilities, and a competent and committed Pathology-Breeding team are required. He gave the procedures for the identification and deployment of diverse R genes through DM/ blast management strategy. He gave complete procedure of studying biology and epidemiology of pathogen. Similarly, molecular genetics help in characterisation and establishment of new pathotypes.

DM pathotypes are being maintained at ICRISAT, Patancheru and used for green house screening. He informed that screening of large numbers of germplasm accessions and breeding lines was done at ICRISAT and a number of resistant germplasm/lines have been identified. Genotypes including P 310-17, P1449-3, IP 18292, IP 18293, IP 18294, IP 18295 and IP 18298 with high levels of resistance have been identified and strategically utilised in resistance breeding at ICRISAT. A number of DM resistant QTLs effective against diverse Indian pathotypes of *Sclerospora graminicola* were transferred to the commercial B-lines (843B, 81B) and R-lines (H 77/833-2, ICMP

451). Development and commercial deployment of DM resistant version of HHB 67 is the first success-story of marker assisted breeding in field crops in public domain in India. Two popular hybrids are being improved for DM resistance (GHB 538 and HHB 67 second cycle improvement).

He gave the significance of blast disease which is now being considered as a potential threat to pearl millet productivity in India. It is economically the second most important disease after downy mildew. Work on characterisation of blast for virulence diversity has been undertaken. New host differential set comprising of ICMB 93333-P1, ICMB 97222-P1, ICMB 01333, ICMB 02444, ICMR 06444, 863 B-P2, ICMR 06222, ICMR 11003, IP 21187-P1 and ICMB 95444 were identified. Promising pearl millet blast resistant lines viz. IP 7846, IP 11036, IP 21187, ICMB 92777, ICMR 06222, ICMR 06444, ICMB 01333, ICMB 97222, across AICPMIP locations (2015-17) were utilised. Inheritance and allelic relationship study indicated the same dominant gene for resistance in ICMB 93333, ICMB 97222, ICMR 06444, ICMR 06222, ICMR 11003 and IP 21187 against Pg 45 and Pg 53. Screening of the crosses against diverse pathotypes was done to identify diverse R genes. Discovered major effective QTLs/alleles from the biparental mapping populations for blast resistance in pearl millet.

He suggested some points to be kept in mind for further strengthening the program and these were: To monitor virulence shift in the pathogen and breakdown of resistance in the released hybrids in the farmers' fields. Additional sources of resistance should be identified and utilised to diversify the genetic base of pearl millet hybrids for DM and blast resistance. Allelic relationships among the resistance genes that should be studied to utilise diverse genes in resistance breeding programs. Pyramiding of DM and blast resistance QTLs in the parental lines of farmers preferred hybrids. Insight into the molecular interaction between effector and R protein can help in designing more rational breeding strategies. A constant interface between pathologists and breeders would assist to develop disease-resistant and durable hybrids.
SM Paul Khurana, Amity Institute of Biotechnology, India presented a paper on 'Strategies for Biomanagement of Fusariam Wilt of Banana'. Banana is an important food and one of the export fruits from many tropical countries. This is an affordable food/dessert for millions in 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. 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, the use of resistant varieties alone is not sufficient to be implemented in the field due to a lack of consumer preference. Due to these problems, the use of biocontrol agents gained importance. Bioagents have the potential to protect and promote plant growth by colonizing and multiplying both in the 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 the potential to create new mechanisms or strategies for the crop protection. *Trichoderma* spp., acts as an interactive agent in the 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 the 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. Biocontrol agents/strategies viz. *Trichoderma* spp., P. *fluorescens* were found effective against *Fusarium* wilt of banana in the field.

SR Niranjana, Gulbarga University, India presented a paper on 'Perspectives and Challenges of Plant Growth Promoting Rhizobacteria Application for Crop Improvement- A Case Study'. He highlighted the importance and role of Plant Growth-Promoting Rhizobacteria (PGPR) viz. *Bacillus sp., B. subtilis, Azotobacter sp., Arthrobacter sp., Serratia marcescens, Pseudomonas fluorescens, Enterobacter* in plant growth promotion and suppression of biotic and abiotic stresses in crop plants. He explained that PGPR 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 the management of tomato disease using phosphate solubilising bacteria. 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 solubilising 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 solubilising indole acetic acid-producing rhizobacteria, is more suitable compared to phosphate solubilizing rhizobacteria (PSRB) and indole acetic acid producing rhizobacteria (IRB) to improve plant health of tomato.

Dinesh Singh, ICAR-Indian Agricultural Research Institute, India presented a paper on 'Management of Bacterial Wilt of Tomato incited by *Ralstonia solanacearum* through Bacterial Antagonists'. He gave the list of bacterial diseases of tomato crops. Bacterial wilt of tomato caused by *Ralstonia solanacearum* (Smith) Yabuuchi is one of the most devastating diseases, 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 discolouration and if the stem is cut crosswise, drops of white or yellowish bacterial slime exude from the vascular tissue. The pathogen spreads via soil, in which it survives for varying periods of time and irrigation water.

Biological control of bacterial wilt of tomato crop through antagonistic bacteria is an alternative approach to reduce disease incidence. Several bacterial antagonists such as *Actinomycetes sp., Azotobacter chroococum, Bacillus spp., Enterobacter spp., Pseudomonas spp., Streptomyces* spp., 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 the 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 B. *subtilis* whereas, strain DTPF-2 belongs to P. *koreensis* and DTPF-3 belong to P. *fluorescens*. In the 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 B. *subtilis*. 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%). P. *agglomerans* was also found effective to control wilt disease of tomato under glasshouse conditions.

In field experiment of seedling dip with a mixed and alone application of bioagents in tomato plants, minimum wilt disease intensity of 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.

SC Dubey, ICAR-National Bureau of Plant Genetic Resources, India presented a paper on '*Trichoderma* as Biological Control Agent for Integrated Disease Management and Healthier Soil and Plant for Sustainable Agriculture'. He discussed soil-borne diseases viz. root rot, crown rot, wilt, damping off, collar rot, caused by *Fusarium, Rhizoctonia, Sclerotinia, Sclerotium, Pythium, Phytophthora, Verticillium* and their survival through hyphae, sclerotia, conidia, chlamydospores and other fruiting structures. Disease management using biological control agents attracted more attention due to the development of resistant strains of plant pathogens against chemicals, adverse effects of non-judicious application of fungicides leading to outbreaks of new diseases and environmental pollution.

Among the various types of biological control agents, *Trichoderma* species were found to be effective against a large number of plant pathogens. *Trichoderma* is having the 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 is 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 bioformulation Pusa 5SD and soil application bioformulation Pusa Bio-pellet 10G was 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 protecting 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 disease, 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. Thus, he concluded that compatible and environment-friendly techniques are the need of the diseases and to sustain the production of crops.

Pratibha Sharma, Sri Karan Narendra Agriculture University, India presented a paper on 'Endophytic Fungal Bioagents in Plant Disease Management'. She narrated that fungal endophytes that have been identified in stem, leaves and roots of monocots and dicots. 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 bacteria and produce active secondary metabolites, that have antimicrobial properties. Secondary metabolites produced by endophytes 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.

Trichoderma is a well-known antagonist and widely used biological control agent against several economically important plant pathogens. It is also playing a vital role in the industrial application for the 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*. 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. Other possible areas of research are the practical application of phytoremediation by endophytic Trichoderma and its ability in biodegradation.

Rita S Majumdar,Sharda University, India presented a paper on 'Phyto-mediated Recovery of Soil Health'. Modernization has become an integral part of society and a lot of new younger cities are 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 and 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
Co-chairs: C Manoharachary, Rajan Sharma
Rapporteur: Suseelendra Desai

MP Thakur, Indira Gandhi Krishi Vishwavidyalaya (IGKV), India presented a paper on 'Diagnosis and Management of Plant Health using Information and Communication Technology'. Disease diagnosis in the 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 the 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 on 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 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 the 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 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 information to farmers in time for crop health management are Mobile, Smartphone, Mobile voice calling, Video calling, Messaging, Facebook, Twitter, WhatsApp, Telegram, e-mail are, Instagram and You tube.

The new ICT tools which are now widely adapted by the extension personnel in rural areas are the use of platforms 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 (GKMS) project, 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 Whats'app 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 the 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 platforms. 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.

Dilip K Ghosh,ICAR- Central Citrus Research Institute, India presented a paper on 'Current Research on Diagnosis and Management of Citrus Greening Disease in India'. He gave brief introduction about the citrus industry and citrus greening disease (CGD) in India/ other countries. Citrus greening (Huanglongbing / HLB) is a devastating disease of citrus which is associated with the phloem limited, gram negative bacterium *Candidatus Liberibacter asiaticus*. 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 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 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 the 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, loop mediated isothermal amplification (LAMP)-based diagnostic tools etc have been developed and are now being used routinely for detection of Ca. *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 'C*a. L.*

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.

VK Barnwal, ICAR-Indian Agricultural Research Institute, India presented a paper on 'Novel Approaches for Virus Detection: A Case Study of Banana Viruses'. He gave importance of banana (Musa sp.) as fruit crop with total annual world production of 114.1 m tons. India is the largest producer of banana with an annual output of 29.1 m tons and 34.42 tons/ha productivity. Banana occupies 13% area among the total area under fruit crop in 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 nucleic acid-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 of 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 (LAMP) 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.

V Celia Chalam, ICAR- National Bureau of Plant Genetic Resources (NBPGR), India presented a paper on 'Role of Quarantine in Biosecurity against Plant Viral Diseases in Asia-Pacific'. She explained several instances of inadvertent introduction of viruses along with introduced planting material into a country. Trade and exchange of germplasm at the 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 the 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 the availability of antisera, viral genome sequences in GenBank, detecting an unknown/ exotic virus etc. Also strengthening of infrastructure, capabilities and methodologies for the 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 the 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. She emphasized the need for the establishment of a Asia-Pacific Diagnostic Network for Plant Viruses which 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.

Jameel Akhtar, ICAR- National Bureau of Plant Genetic Resources (NBPGR), India presented a paper on 'Minimising Risk of Introduction of Exotic Pathogens associated with the Import of Plant Genetic Resources into India'. He pointed out his concern on the movement of seed-borne/ seed-transmitted plant pathogens particularly quarantine pests through trans-boundary movement of plant genetic resources. He has explained plant genetic resources (PGR) are an important source for breeding programme for developing new varieties resistant to biotic/abiotic stresses or high yielding varieties for food security. However, PGR carries an inherent 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. Critical quarantine examination of importing material at ICAR-NBPGR. New Delhi resulted in interception of a large number of exotic pathogenic fungi on various crops from different parts of the world.

The interceptions included *Claviceps purpurea in Triticum aestivum, Fusarium oxysporum f. sp. cucumerinum in Cucumis sativus, Monographella nivalis in T. 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) and other pathogens with wide host range and limited distribution and are of quarantine significance to India. Interception of a large number of pathogens of quarantine significance on a wide range of crops from different countries emphasises the pivotal role of plant quarantine in minimising the risk of introduction of exotic pathogens associated with PGR importing into the country, otherwise huge losses would have occurred due to exotic pathogens/diseases.

R Sudeep Toppo, ICAR-Indian Agricultural Research Institute (IARI), India presented a paper on 'Exploration of undiscovered Fungi of Meghalaya State of North East Region of India'.Meghalaya state is the most wet region of India known for rich fungal diversity. Therefore, the 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 the 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. The 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, edaleopsis, 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 the 'Herbarium Cryptogamae Indiae Orientalis' (HCIO) and identified fungal cultures at Indian Type Culture Collection (ITCC), Division of Plant Pathology, ICAR-IARI, New Delhi and their HCIO and ITCC accession numbers were obtained.

RP Pant, ICAR-Indian Agricultural Research Institute, New Delhi, India presented a paper on 'Identification, Characterization and Detection of Viruses associated with Orchids in Sikkim and Darjeeling Hills of West Bengal'. 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 a serious threat to the 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* (VanMV). Besides, *Cucumber mosaic virus* (CMV), *Cymbidium ringspot virus* (CyRSV) and *Bean yellow mosaic virus (*BYMV) have 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 collections. 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. Direct Antigen Coating-Enzyme-linked Immunosorbent Assay (DAC-ELISA) has 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 have 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.

D Pramesh, All India Coordinated Research Project -Rice, University of Agricultural Sciences, Raichur, India delivered a paper on the 'Genomic features of an Indian isolate of rice false smut pathogen *Ustilaginoidea virens*'. He gave the background of rice and the diseases occurring in the crop. 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 discolouration 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 to 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 characterise 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 chlamydospore. Pathogenicity was established by artificially inoculating the pathogen to rice cultivar BPT-5204. The pathogen was mass multiplied and the mycelial-spore suspension was harvested after incubation at 25°C for 15 days. Genomic DNA was isolated using Cetyl Trimethyl Ammonium Bromide (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. The library was subjected to paired-end sequencing in Illumina NextSeq 500 platform it yielded approximately 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. A 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. This is the first report of complete genome sequencing and annotation of U. *virens* from India.

RN Kharwar,Banaras Hindu University, India presented a paper on “Fungal Endophytes: A Treasure Trove of Biodiversity, Host Security, Antimicrobial and Myco-nanotechnology’. He highlighted that fungi are a group of microbes which have been the important source of bioactive compounds for 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 a new mechanism of action within the cellular metabolism, and thus explored fungal endophytes of *Azadirachta indica, Aegle marmelos, Tectona grandis, Madhuca longifolia* etc., and found new bioactive compounds with interesting results. For isolating the improved and cryptic metabolites, *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 nanoparticles using aqueous solution of silver nitrate (AgNO3), and tetra auro chlorate (HAuCl4), respectively. A. clavatus and C. globosum induced AgNps were antimicrobial in nature. Ultra Violet- Visible Spectroscopy (UV-VIS), transmission electron microscopy, Atomic force microscopy, Fourier-transfoem infrared (FTIR) microscopy and X-ray diffraction were used to characterise the NPs.

T Prameela Devi, ICAR-Indian Agricultural Research Institute, India presented a paper on the ‘*Bipolaris - Curvularia - Cochliobolus* Complex-their Phylogenetic and Taxonomic Re- evaluation and DNA Barcoding’. She narrated that *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 National Center for Biotechnology

Information (NCBI) database. Five species of *Bipolaris* and 16 species of *Curvularia* 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. spicifera clustered with Cuvularia along with their teleomorphic (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, glyceraldehyde-3-phosphate dehydrogenase (GPDH) gene, large Subunit (LSU), small subunit (SSU) and translation elongation factor 1-alpha (tef-1) for *Curvularia* were analysed separately using five species of *Bipolaris* and 16 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 Barcode of Life Data System (BOLD) and the DNA barcodes were obtained.

UN Bhale, Arts Science and Commerce College, India presented a paper on 'Mycorrhizal Diversity of Weed Species in Degraded and Deficient Land Ecosystems'. The studies were conducted in the Deccan Plateau Zone of India and is located in Osmanabad district of Marathwada region which is prone to drought, rocky and dry with low and uncertain rainfall. The standard procedures were used to estimate the Arbuscular Mycorrhizal Fungi (AMF). AMF root colonization ranged from 40.62–84.37%. The highest colonization was recorded in *Phyllanthus niruri* (84.37%) and least in *Cocculus hirsutus* (40.62%) in rabi season. In case of kharif, root colonisation ranged from 43.75–81%. The highest colonisation was recorded in Dichanthium caricosum (81%) and least in *Adenostemum alavenia* (40.62%) in Kharif season. Six species of AMF i.e. *Acaulospora rehmii, Glomus macrocarpum, G. microaggregatum, G. delicata, G. geosporum and Sclerocystis* sp. were found. *Acaulospora, Glomus and Sclerocystis* species were found dominanting both the season.These can be used in plant disease management and reclamation of wastelands, as a biofertiliser and bioprotector.

SK Prashanthi, University of Agricultural Sciences, India presented a paper on 'Avirulence Gene based Profiling of *Magnaporthe oryzae* Isolates and Validation on Monogenic Lines'. She presented the importance of rice and the constraints particularly diseases for hampering the rice yield. *Magnaporthe oryzae* is one of the most devastating fungal pathogens 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 AvrPi9 (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, she proposed to pyramid Pi33 gene along with other Pi genes in elite rice varieties for durable blast resistance in future.

Technical Session VII: Plant Health Management - Case Studies
Co-chairs: GD Sinniah, Umer Iqbal
Rapporteur: Dilip K Ghosh

Vaibhav K Singh, ICAR-Indian Agricultural Research Institute, India presented a paper on 'Wheat Blast Dis-ease- A Recent Danger to South Asia's Wheat Production and Our Preparedness'. Wheat blast caused by the fungus *Magnaporthe oryzae* pathotype triticum, 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% depending on genotype, year, environment and 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 M. *oryzae* pathotype Lolium (MoL) was later confirmed as a causal agent. South Asia particularly Bangladesh has witnessed the first occurrence of this disease outside South America during February 2016. A vast area of around 15,000 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 January 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 Department of Agriculture, Cooperation & Farmers Welfare (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 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-Indian Institute of Wheat and Barley Research.

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 have been trained 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 have already been taken up by the scientists in tandem with other initiatives like deputation of Indian Scientists to Bolivia and Bangladesh for training them in advance techniques to combat this pathogen.

Kajal K Biswas, ICAR-Indian Agricultural Research Institute, India presented a paper on 'Current Status of Cotton eaf curl begomovirus complex in India: Disease Incidence, Genomics, Virus Distribution and Molecular Basis of Pathogenicity'. *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 six 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 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 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). Bu 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 beta-satellites are members o combinants. Four species of Cotton leaf curl Multan beta-satellite (CLCuMB) and all were re-alpha-satellites, Gossypium darwini symptomless alphasatellite (GDarSLA), cotton leaf curl Multan alphasatellite (CLCuMA), cotton leaf curl Burewala alpha- satellite (CLCuBuA) and Croton yellow vein mosaic alphasatellite (CrYVMoA) were identified. The present study demonstrated that the complex interaction of recombinant CLCuMuV-Ra strain, recombinant beta-satellite CLCuMB and divergent alpha- satellites is associated with CLCuD outbreak in NW India. Two infectious clones (DNAA-A), 1.4 mer tandem repeat of CLCuMuV-S-11 (pCAMBIA+S-11) and CLCuKoV-IARI-45 (pCAMBIA+IARI-45); two infectious clone of beta-satellite (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 agromobilised. The infectivity of these clones was studied in cotton and tobacco plants. No symptoms were observed in cotton and tobacco plants agro-inoculated with DNA-A construct alone but accumulation of DNA-A was detected. When DNA-A construct was co-inoculated with the beta-satellite the construct produced symptoms.

Jiban Kumar Kundu, Crop Research Institute, Czech Republic presented a paper on 'Management of Wheat streak mosaic virus, an emerging disease of the wheat'. *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 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 using Wsm2 gene-based cultivars is 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.

RC Mathuria, ICAR-Indian Agricultural Research Institute, New Delhi, India presented a paper on 'Eco-friendly Management of Banded Leaf and Sheath Blight of Maize'. He narrated that 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 Southeast Asian countries, is caused by a soil-borne 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 the 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.

Robin Gogoi, ICAR-Indian Agricultural Research Institute, New Delhi, India presented a paper on the 'Biochemical & Molecular basis of Chemically induced Defense Activation in Maize against Banded Leaf and Sheath Blightisease'.Banded leaf and sheath blight (BLSB) caused by R*hizoctonia solani f. sp. sasakii* is a major disease of maize. The disease can be managed by us- ing a combination of different management strategies at some level. 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 resis- tance in maize hybrid variety Vivek QPM-9 applying fungicides at recommended dosages and two plant defense inducers viz., salicylic acid (SA) andjasmonic 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 Ascorbate peroxidase (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.

Santosh Kumar, Bihar Agricultural University, India presented a paper on 'Status of Major Diseases of Makhana in Koshi Region of Bihar and Correlation of Weather Parameters with Alternaria Leaf Blight and Spot'. 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 A. *alternata* and A. *tenuissima*, air-borne pathogens, causing leaf blight and spot respectively, which appears every year with varying intensity and render heavy reduction in the yield of nut. High temperature (31oC) 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 geophytopathological model for the prediction of *Alternaria* leaf blight and spot disease has been developed.

Vinod Kumar, ICAR-National Research Centre on Litchi, India presented a paper on '*Alternaria* Disease- an Emerging Problem of Litchi (Litchi chinensis) in India'. India is one of the leading litchi (*Litchi chinensis Sonn*.) producing countries in the world. Generally, 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 phases viz. leaf blight on nursery plants and orchard trees in the vegetative phase, panicle or inflorescence blight and fruit blight in the 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 the nursery stage, and at reproductive phase blighting of panicle and fruits occurs that was first noticed during April-June, 2014. At the 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 inoculum comes 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. 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 atmospher-ic 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 survives in extreme conditions, climate change in recent past, with a shift towards more cloudy weather and intermittent rains during the reproductive phase of litchi that decreases temperature and increases humidity, has aggravated the damaging potential and losses caused by this disease.

Krishna Kumar, ICAR-Indian Institute of Pulses Research, India presented a paper on 'Harnessing the Potential of Bio-inoculants for Disease Management and Soil Health'. He discussed bacteria, fungi and archaea that colonize different plant parts collectively called as plant-microbiome. Plant-Microbe interactions play a key role in soil structure and function in natural and managed agricultural soil. Beneficial microbes survive and promote the growth of crop plants. Plant growth promoting microbes (PGPM) benefits plants and soil by different mechanisms i.e.provide nutrients to plants, protects plants from biotic stresses altering the levels of peroxidases, superoxide dismutases, L-proline, polyphenoloxydase and production of 1- aminocyclopropane-1-carboxylic acid (ACC) deaminase; protects plants from biotic stresses through siderophores, HCN, antibiotics, glucanases, chitinases, induced systemic resistance and acquired systemic resistance. He highlighted that the 'green revolution' has enabled farmers to be self dependent, but in recent times the unlawful use of chemical fertilisers and pesticides are making the soil unproductive and ultimately hindering the ecological equilibrium.

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 the growth of plants if provided with pathogen suppressing strains of microbes and probiotics (silver bullet approach). Management of diseases and soil health through bioinoculants is going to play a prodigious role in establishing green economy. At present only few effective micro-organisms have been registered as bio-pesticides and formulations developed so far are dominated by *Trichoderma* sp., *Pseudomonas* sp. and *Bacillus* sp. Shelf life and spuriosity of formulations available in the market are of global concern and thereafter the illiteracy and unawareness about the use of bio- inoculants among the end-users play role as restricting factors. Industries must provide standard bio-pesticides in harmonization with international regulations to produce and supply high quality bio-pesticides. 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, utilisation and technology if deployed appropriately, biopesticides have the potential to bring sustainability to global agriculture for food and feed security.

Ramji Singh, Sardar Vallabh Bhai Patel University of Agriculture & Technology, India presented a paper on 'Mitigating Drought Stress in Rice using *Trichoderma harzianum*'.He gave the importance of rice, drought and rainfed area of rice in India and yield losses due to drought. He gave the strategy of drought management as cultivation of drought-tolerant rice varieties, application of hydrogel a water-absorbent polymer compound, use of *Trichoderma* spp. as seed biopriming, which have been found to enhance the root and shoot length and their biomass. He reported that the treatments helped in the reduction of leaf rolling and free proline content and increased leaf area index, relative water content and membrane stability index . There was also an increase in catalase and peroxidase activity for greater scavenging activities for the free radicals and other harmful compounds generated by the drought stressed plants. The colonisation of rice seed by drought tolerant T. *harzianum* strains, enhanced growth, and delayed the drought response in rice that proved to be valuable in the production of these important crops particularly under drought conditions.

Shvaji S Kumble, Shivaji University, India presented a paper on 'Combined Effect of Soil Salinity and Some Agrochemicals on the Growth of Rhizobia'. In the present investigation 51 isolates of Rhizobia were isolated from *Crotalaria pallida* Ait., C. verrucosa L, C. *retusa* L., *Clitoria ternatea* L., *Vigna unguiculata* (L.) Walp. sub sp. *cylindrica* (L) Eseltine, *Vigna mungo* (L). Hepper and *Mimosa pudica* L. from the 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 out of these 7 isolates were highly resistant to NaCl and tolerated up to 8 % NaCl. To study combined effect of agrochemicals and soil salinity on the development of soil tolerance in Rhizobia, all the above isolates were grown in Yeast Extract Mannitol (YEM) broth containing 8% NaCl with fungicides (Kocide 101, Ridomil, Benofit, Blitox, Roko, Bavistin and Kavach), herbicides (Dhanuka Dhanuzin, Sencor, Matin, Krizin, Mera- 71 and Atrazin), Insecticides (Krinet. Prime, Shark and Monosaan) and antibiotics (Nalidixic acid, Cephalexin, Trimoxazole, Chloramphenicol, Norfloxacin, Furazolidore, Norfloxacin, Oxytetracycline, Ampicillin, Tetracycline, Gentamicin, Kanamycin, Amikacin, Streptomycin and Cefotaxime) all at 10-100 µg/ ml. There was nearly 99-100% inhibition of NaCl resistant *Rhizobium* isolate due to the combined effect of NaCl and above mentioned agrochemicals.

KB Yadahalli, University of Agricultural Sciences, India presented a paper on 'Studies on Black Rot of Cabbage caused by *Xanthomonas campestris pv. campestris*'.He briefly introduced the crop, its importance, area, production and diseases. The survey for the incidence and severity of the black rot of major cabbage growing areas of northern parts of Karnataka revealed 48.0 to 57.0% disease incidence and 18.0 to 25% disease severity in the crop. The treatments viz. seed treatment with a combi product (streptomycin sulphate 90% + tetracycline 10 % + copper oxychloride) + seedling dip with *Pseudomonas fluorescens* + foliar spray of the combi-product followed by foliar spray of P. *fluorescens* was found superior for the management of the disease.

Kalyan K Mondal, ICAR-Indian Agricultural Research Institute, New Delhi, India presented paper on 'XopC2 T3SS Effectorof *Xanthomonas axonopodis* pv. *punicae* Suppresses Pomegranate Immune Responses to Support Bacterial Growth during Blight Development'. He highlighted that *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 a decrease in crop export. Xap depends on the TTSS-effectors to overcome the pomegranate innate immunity. He said, our previous studies revealed that Xap secretes six 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 plants 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 event in pomegranate, presumably to support Xap for its multiplication in the living plant tissues for a sufficient time during pathogenesis. Altogether, this study indicates that the 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 T3SSeffectors will provide new avenues to manage bacterial blight of pomegranate in the field.

Mohan Kumar Biswas,Institute of Agriculture, Visva-Bharati, India presented a paper on 'Improvement of Soil Health through the Enriched Spent Mushroom Substrate (SMS) and its Effects on Plant Health, Productivity and Wilt Incidence of Tomato'. He narrated that the cultivation of edible mushrooms also generate a large quantity of spent mushroom substrate (SMS) or compost. The microbial flora present in the spent substrate have an antagonistic effect on the soil-borne pathogens. SMS 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 the earthworm. SMS is also effectively bio-transformed into vermicompost by the activity of earthworm. Spent mushroom-based fertilisers are easily used up by the plants in both green house conditions and field conditions. The nitrogen fixing bacteria *Azotobacter, Azospirillum* and *Rhizobium* were grown well on SMS. Maximum height (66.3 cm), average shoot biomass (129g), average root biomass (33.3g) and yield (1.48 kg) of tomato plant were obtained from the SMS enriched with *Azotobacter* spp. + *Azospirillum* spp. (1:1) followed by the SMS enriched only with *Azotobacter* spp. Three well known biocontrol 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 conditions. 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 exhibited (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 SMS + 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 vermicompost 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 vermicompost were compared with others organic composts against wilt diseases of tomato. Among the different treatments, compost repaired with SMS + FYM + *Azotobacter* spp. (1:1:0.01%) and earthworm E. *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 days after transplanting, maximum average dry shoot bio-mass/plant of 145g, highest dry root biomass of 53.0 g and maximum yield of 1.85 kg/plant followed by Earthworm 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 minimise the wilt incidence in the field.

NM Praveen, Kerala Agricultural University, India presented a paper on 'Correlation of Weather Parameters with the Development of *Alternaria* Leaf Blight of Gerbera'.Gerbera (*Gerbera jamesonii*), the most popular cut flower crop is being marketed in the international cut flower industry and secures the fourth position globally. 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 three weather parameters viz., temperature, RH and rainfall. For this, a purposive sampling survey was carried out in three districts of Kerala viz., Wayanad, Malappuram and Thrissur during rainy, winter and summer seasons to observe the occurrence of *Alternaria* leaf blight disease. The 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 A. *alternata* and A. *tenuissima*. 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 a positive correlation with temperature however, reverse relation existed with relative humidity and rainfall. Percent disease incidence (PDI) and percent disease severity (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 a sudden upsurge in temperature immediately after the wet spells.

Technical session VIII: Plant Health Management – Research Trends
Co-Chairs: Anthony B Obligado, Tashi Uden
Rapporteur: Robin Gogoi

MB Waghmare, India presented a The New College, paper on 'Integrated Capability of Supplementary Agrochemicals on the Growth of Carbendazim Resistant *Botrytis cinerea* causing Leaf and Flower Blight of Rose'. He told that 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 these fungal diseases, leaf and flower blight caused by B. *cinerea* is very common and serious threat to the rose plantation. These diseases are managed by farmers following various management practices. Four fertilisers, three herbicides and five different micronutrients were tested against B. *cinerea* along with carbendazim. 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 the growth of pathogen with its increased concentration in the Czapek Dox Agar medium. Among the fertilisers, DAP inhibited the growth of pathogen at 0.1% with 1000 µg/ml carbendazim, while Samarth, urea and muriate of potash decreased the growth as the increased concentrations. Among micronutrients cobalt and zinc inhibited the growth of the pathogen at 0.1 µg/ml, with 1000 µg/ml carbendazim, while iron, manganese and copper reduced the growth as the concentration is increased.

Asha Chaubey, CSIR-Indian Institute of Integrative Medicine, India presented a paper on 'Influence of Biofertilizer and Biocontrol Agents on Medicinal and Aromatic Plants'.She explained the mode of action and benefit of the use of bio-fertilisers and biocontrol for crop production particularly medicinal and aromatic plants and the management of biotic as well as abiotic stresses of crops. The treatment of *Trichoderma* in *Monarda citriodora* and *Tagetes minuta* was found beneficial to increase fresh herb yield of 13.89% and 36.36% and oil recovery of 36.36% and 71.43%.
K Karuna, All India Coordinated Research Project (AI-

CRP)-Sunflower, University of Agricultural Sciences, Bengaluru, India presented a paper on'Sunflower and Modelling of the Diseases'.She narrated major diseases of sunflower viz. 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,a=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. 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 six years. The severity of diseases can be predicted one/two weeks prior by considering weekly observations of weather parameters.

IK Kalappanavar,University of Agricultural Sciences, India presented a paper on Management of Leaf Rust and Insects of Wheat by New Pre-mix Molecule. He gave the importance of wheat, its diseases viz. rusts and insect pests i.e. termites, aphids, shoot fly, etc. He gave the importance of insecticide and fungicide pre-mixture as a seed treatment on wheat to manage both diseases and insect pests. He conducted the experiments and concluded that the treatment, Imidacloprid 18.5% + Hexaconazole 1.5%FS (RIL-071/F1) (20% FS) @ 2.0 ml/kg seed was significantly superior for the management of wheat rust and insect pests (termites and aphids) and recorded the maximum grain yield. It is relatively safe to natural enemies and also non-phytotoxic to the wheat crop.

Yashoda Hegde, University of Agricultural Sciences, India presented a paper on 'Role of Endophytes in Mitigating Soil-borne Fungal Diseases of Groundnut'. She discussed the importance of endophytes associated with different plants. Endophytes are the microorganisms that reside inside healthy plant tissues without causing any detectable disease symptoms to the host. An attempt was made to isolate and evaluate the endophytes against soil-borne diseases in the groundnut and to study their mode of action. A total of 124 endophytes including 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. Among the genotypes, the 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* conditions against soil-borne 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 soil-borne diseases, LFDwAc-7 recorded the least disease incidence of stem rot (33.33%) and root rot (27.78%) and higher plant growth parameters. 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 the number of leaflets were more in soil drenching method, whereas fresh and dry weights were 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 the 7th day after inoculation and endophyte N. sphaerica (LFDwAc- 7) recorded more of PO, PPO and PAL activity.

RR Pandey, Manipur University, India presented a paper on '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'. Arbuscular mycorrhizal fungi (AMF) are the key component of the soil microbial communities in agro-ecosystems and facilitate multiple benefits to the host plants. Knowledge about the occurrence and diversity of native AMF associated with agricultural crops of a specific area is essential for utilizing them in any application. Therefore, the community composition of AMF was assessed in the rhizosphere soil and their colonization patterns in the roots of indigenous scented black rice cv. Chakhao amub during harvesting period under sub-tropical terrace cultivation system of Manipur, North Eastern (NE) India. A total of 9 AMF spore morphotypes belonging to six genera were isolated from the 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.

Further, 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- sterilised field soil as the substrate with seven different combinations of bioinoculants. 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 from the 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 crop production in NE India.

AK Senapati, Odisha University of Agriculture & Technology, India presented a paper on 'Impact of Bio-agents on Blast, Sheath Blight, Bacterial Blight and Drought Tolerance in Rice'. The investigation was carried out on the 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 (OT-3 and OT-8) were isolated from native soil. 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 were applied as seed treatment @ 5 g/ kg 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 isolates T-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 all these advances, 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 biochemical 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 defense 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. The present study made a novel approach to manage two stresses with a 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.

Muhammad Sahid, Sultan Qaboos University, Omanpresented a paper on 'Evaluation of resistant Tomato Germplasm against Tomato Yellow Leaf Curl Disease to Improve Crop Productivity in Oman'. He presented a brief account of tomato production, emergence and distribution of tomato yellow leaf curl disease (TYLCD) in Oman, management practices, etc. TYLCD has become a major constrain for tomato (*Solanum lycopersicum*) production in Oman. The development of tomato lines with resistance against the begomoviruses that cause TYLCD has become an important target in tomato breeding programs worldwide. The study assessed 14 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 Tygene-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 the 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.

Poly Saha, College of Agriculture, BCKV, India presented a paper on 'Application of a New Chemical Molecule against Diseases of Corn'. The field experiment was conducted to document the presence of different diseases of corn variety 'PAN 6015'. 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 other fungicides currently being used. The prevalence of diseases was *Curvularia* leaf spot, northern leaf blight, stalk rot of maize, charcoal rot, Turcicum leaf blight. Highest disease incidence (45.5%) and severity (PDI: 75.09) were observed in the 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). The 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 bioefficacy 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 the 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. 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.iwas 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 program.

SK Mengane,MH Shinde Mahavidyalaya, India presented a paper on the 'Biosynthesis, characterization and antifungal activity of silver nanoparticles from *Lactuca virosa*'. He described 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 hazardous and 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 a 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 synthesised silver nanoparticles were also characterised by UV-Vis spectrophotometry, Fourier-transfoem Infrared (FTIR) spectroscopy, Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM). The reaction progress has been analysed using FTIR that revealed the role of L. virosa leaves extract as a reducing agent in nanoparticle-synthesis. The size of prepared AgNPs is in the range of 40- 50 nm, which determined by scanning electron microscope and transmission electron microscope. The AgNPs, synthesised by L. virosa leaves extract is a green solution with potent antifungal activities against plant pathogenic fungi *Fusarium oxysporum, Alternaria alternata* and *Macrophomina phaseolina*.

VS Chatage, KR Mahavidyalaya, India presented a paper on 'In vitro Antifungal Activity of Plant Latex Extracts against Resistant Isolates of Pathogens Associated with Ivy Gourd (*Coccinia indica* Wight & Arn.)'. The fruit rot of ivy gourd, *Coccinia indica* (Wight and Arn.) 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 *Jatropha curcus, Calotropis gigantea*, *Ficus bengalensis* and F. *glomerata* were evaluated. The inhibitory effect was tested by food poisoning technique and determined minimum inhibitory concentration. Due to the presence of bioactive molecules, the latex extracts showed significant inhibition in different concentrations. J. *curcus* showed a 100% reduction of radial growth of B. *tetramera* and A. *pluriseptata* at 75% conc. To some extent, F. *bengalensis* also showed a significant reduction of radial growth of M. phaseolina and G. candidus at 100% concentration.

SG Jagtap, Shivaji University, Kolhapur, India presented a paper on 'Evaluation of Trichoderma spp. for Biological Control of the Charcoal Rot of Maize'. The studies showed that *Trichoderma* spp. are not only parasites of fungal plant pathogens but also can produce antibiotics. Besides, certain strains can induce systemic and localised resistance to several plant pathogens. Moreover, some strains may enhance plant growth and development. There was variation in MICs of carbendazim among the sixteen isolates of *Macrophomina phaseolina* causing charcoal rot of maizeVar. African tall. Among these 16 isolates, isolate Mp3 was sensitive tolerating one 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* by dual culture technique for their biocontrol potential. Among the six species of *Trichoderma*,T. *pseudokoningii* showed maximum antagonistic potential (79.63%) against resistant isolate of M. *phaseolina*. In the remaining species of *Trichoderma*, T. *koningiopsis* showed 78.40% inhibition, T. virens showed 76.33%, T. *atroviride* showed 73.71%, T. viride showed 69.63% and T. *harzianum* gave 67.04% inhibition of M. *phaseolina*. 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%).

Shrishail S Navi, Iowa State University, USA presented a paper on 'Impact of Seed Treatments with Biocontrol Agents on Major Yield- reducing Soil- borne Pathogens of Soybean. Thetop 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 (BCAs). Initially, the BCAs were evaluated *in vitro*, in dual culture plug method to assess their outcome on growth reduction, antagonism and mycoparasitism of target pathogens. Subsequently, the BCAs 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 the management of some of the major soil-borne pathogens and diseases of soybean.

Mohd. A Malik, Government Post Graduate College, India presented a paper on Plant Health and United Nations Sustainable Development Goals (SDGs). He presented background of SDGs based on the Millenium Development Goals (MDGs). On September 25th 2015, countries adopted a set of goals to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda achieved over the next 15 years. On 1 January 2016, the 17 SDGs of the 2030 Agenda for sustainable development was adopted by world leaders in September 2015 at an historic UN Summit which officially came into force. The new Goals will universally apply to all, countries will mobilise efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. The SDGs, also known as Global Goals, build on the success of the MDGs and aim to go further to end all forms of poverty. The new Goals are unique in that they call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. They recognise that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection.

While the SDGs are not legally binding, governments are expected to take ownership and establish national frameworks for the achievement of the 17 Goals. For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and everyone on planet. He presented eight goals, 21 targets and 60 indicators of MDGs with that of 17 goals, 169 targets and 364 indicators of SDGs. Five 'Ps' i.e. People Partnering for Peace and Prosperity on the Planet. Facts and figures of all 17 SDGs and action plan to achieve the goals have been given.

Technical Session IX: Panel Discussion Policy and Capacity Development on Soil and Plant Health
Co-Chair: SR Niranjana, CL Acharya
Rapporteur: Pratibha Sharma

CL Acharya, Ex-ICAR, India flagged "Issues on Soil Health for Policy and Capacity Development" and said that "Health of any Nation Depends on the Health of the Soil". He spoke on issues like water erosion, diversion of agricultural lands for purposes other than agriculture, crop residue removal and in-situ burning in the Asia-Pacific Region (APR), soil sickness due to imbalanced nutrient use, low or no input of organics, low nitrogen use efficiency (NUE), garbage dumping vis-à-vis quality of organic manure produced, shrinking water resources, contamination of water with urban and industrial effluents, large area under rain-fed agriculture, over mining of underground water loaded with heavy metals etc. but said that inspite of all this we need to produce more to feed the growing population against the challenges of climate change, and commitment of climate pledge i.e. green house gas (GHG) emissions to be brought down by 33- 35% of the 2005 level by 2030. He informed that in India annually 5.3 billion tons of top soil with 5.37 to 8.4 mt of nutrients is lost through water erosion causing 13.4% loss in crop productivity worth $30 billion and about 20,000 ha are annually converted to wasteland by brick kiln industry alone removing 540 mt of top fertile soil.

Further, estimates show that in north- west Indian states annually about 23 mt of rice crop residues (containing 0.14 m t of N equivalent worth about ~ $ 150 m) along with micro-fauna and flora are burnt which adversely impacts soil and environmental health. Further, with burning one tone of paddy straw there is a loss of 5.5 kg N, 1.2 kg S, 2.3 kg phosphorous, 25 kg potash, and 400 kg of organic carbon. He discussed various options to improve soil health like enhancing soil organic carbon (SOC) content, balanced fertilisation, Integrated Nutrient Management (INM), conservation tillage, efficient nutrient and water management, rain-water harvesting in water deficit areas etc. and also showed results of long term fertiliser experiments continuing in different agro-ecoregions in India for the last more than 50 years and supporting the positive effects of balanced fertilization and integrated nutrient management with combined use of organic and inorganic fertilisers. He also discussed various strategies for policy and capacity development like need for a land-use policy to save productive lands, providing Soil Health Cards to the farmers, training and incentives for better/ enriched compost/ Vermi preparation, management, need to popularize more efficient management practices and methods of nutrient application like fertigation, policy change for safe disposal of municipal wastes and industrial effluents, incentives rather than punitive measures to farmers promoting greater N-use efficiency. use of alternate energy sources such as solar and wind power in agriculture, conservation agriculture (CA) with *in-situ* crop residue retention as an alternative to residue burning, encouraging private sector to take up soil health care program using principle of soil clinics, diagnosis and recommendations at a reasonable cost.

He emphasised that there is a need to introduce the importance of soil resource and its care in the text books at school and college levels and farming community too to be made aware of soil erosion, losses due to soil degradation, and benefits of soil health improvement through action learning tools explaining the process of soil degradation in a simple and understandable manner. Finally, he said that since soil Health/Quality impacts environmental quality, the answer to the challenges of climate change lies in the Soil and there is a need to develop a Regional Knowledge Platform on Soil and Plant Health in the APR to access and share the new knowledge and technologies within and outside the region.

KS Varaprasad, Senior Consultant, Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok presented a paper on 'Plant Health Issues in Asia Pacific'. He highlighted the points viz. phytosanitation, pest categorisation, crop losses, climate change, pesticide, trade, soil microbes and plant health, digital technologies, capacity-building and other issues of plant health. The phytosanitary issues were plant quarantine legislation and dynamic amendments; harmonising International Plant Protection Convention (IPPC) and Asia and Pacific Plant Protection Commission (APPPC) standards and guidelines with country's plant quarantine legislation i.e. comprehensive biosecurity act; harmonising Convention on Biological Diversity (CBD), World Trade Organization- Sanitary and Phytosanitary (WTO-SPS) Agreement and plant quarantine for safe trade; pest surveillance at country/ the region level and lack of human resource and budget & regional cooperation and coordination; pest reporting and rapid eradication mechanism. In diagnostics, lack of capacities and infrastructure, networking of diagnostic laboratories at the regional level; phytosanitary treatments i.e. lack of research on potential threats; alternatives for methyl bromide for pest destruction; trade-restrictive issues and research on handling bulk consignments for seed and consumption. The issues of pest categorisation at the regional level including emerging pests (mealy bug, mite, leaf miner, stem necrosis, leaf curl complex); well known pests (Locust, brown plant hopper, *Helicoverpa*, *Alternaria*, root-knot); pest of limited distribution (wheat blast, apple fire blight, *Banana bunchy top virus*, pinewood nematode, coffee berry borer, western flower thrips); recently introduced pests (wheat blast, wheat streak mosaic, Fall Armyworm) and not yet reported pests (South American Mega Pest, South American Leaf Blight (SALB), South American Fruit Fly, *Rice yellow mottle virus*, *Maize streak virus*). In crop losses, he emphasised on working for research on methodology, use of remote sensing; defined frequency crop loss estimation; reliable and scientific estimations; potential exotic threats and estimations.

The issues under climate change were the effect of climate variability, extreme events for developing diseases like bacterial wilt; researches on early warning systems and mitigating technologies. The pesticides play a major role in pest management. Issues viz. eco-friendly and traditional options of pest management, researches on label claims; pesticide registration process review particularly with reference to bio-pesticides; research on the combination of chemical and bio pesticides for sustained production and safe trade; regulation on quality and monitoring systems. There are certain issues in trade and phytosanitation viz. phytosanitary-based trade blocks to be identified at the regional level; research and exploitation of pest-free area concept; latest technologies combo (drones, and image diagnostics) for surveillance; bulk consignment research infrastructure for sampling, treatment and pre-export inspections through regional cooperation. Soil Microbes play an important role in plant health. Therefore the emphasis should be given on the upscaling of proven technologies of *Trichoderma* spp., incentives in packaging technologies and bulk productions across the region; policy to enhance research on Plant Growth Promoting Rhizobacteria (PGPR), endophytes and other bioagents; regional body to setup to develop safety, research and trade guidelines on microbial technologies for plant health; exploring research collaborations with Common Microbial Biotechnology Platform, Agricultural Genetics Institute, Hanoi and linking soil quality and plant health needs. Similarly, the transfer of technology for good agriculture in which digital technologies play important role. The emphasis needs to be given for skill development policy for soil and plant health; Massive Open Online Courses (MOOCs) in regional languages and exploit existing Information and Communication Technologies (ICTs) combining digital and farm field schools. Other key issues at regional level viz. knowledge management for all stakeholders; identification of priorities and develop policy briefs;

developing regional databases; sustaining and improving forest ecosystem; integration of soil, water and nutrient effect on plant health; developing modules for capacity enhancement (MOOCs, Farmer Field Schools and other ICT-based content development); awareness and course curricula for school to higher education level; facilitating regional networks and laboratory networks establishment; harmonisation with global initiatives and consolidation of scientific human resource (societies) and link to SDGs.

V Celia Chalam, ICAR-National Bureau of Plant Genetic Resources (NBPGR), India presented paper on 'Capacity Development in Plant Biosecurity and Biosafety in South Asia'. She presented briefly the challenges in transboundary movement of pests along with the material imported for research or commercial purpose. She highlighted the need for capacity building due to trade among South Asian counties, which has the inherent risk of trans-boundary movement of the pests. She discussed key capacity-building areas viz., pest risk analysis, survey and surveillance, development of local pest database, threshold levels for pests, diagnostics for different pests, quarantine treatments, identification of pest-free areas, export certification system and biosafety and transboundary movement of LMOs. In South Asia, there is a need for ready to use dip sticks for diagnosis of viruses and other pests and alternatives to methyl bromide need be developed for disinfestation. For facilitation of export, emphasis should be given to identify pest- free Areas. She proposed A1, A2 Pest List for South Asia in line with EPPO. She suggested the establishment of *'South Asia Plant Pests Diagnostic Network'* (SAPPDN) by South Asian Association for Regional Cooperation (SAARC) and Asia-Pacific Association of Agricultural Research Institutions (APAARI) linking National Plant Protection Organisations (NPPOs) in different countries in South Asia. The National Referral laboratories should be linked with 'National Plant Protection Organisations (NPPOs) in different countries in South Asia. Testing Laboratories in different countries should be accredited. The SAPPDN should look into the preparation of 'Fact Sheets' Protocols. Capacity has to be properly built keeping in view the infrastructure available and there is a need for Roster of Experts on Biosecurity and Biosafety in South Asia. Regional Expert Group on Biosecurity and Biosafety needs to be created with the joint effort of countries through SAARC and APAARI Regional Platform on Biosecurity & Biosafety.

Yuxin Tong, Global Soil Partnership Secretariat, FAO, Rome spoke on 'Policy Need for Soil Health Management' and said that policy shall contribute to addressing global challenges, and meeting international commitments, including the 2030 Agenda for Sustainable Development, where Soil Health could directly or indirectly contribute to achieving several of the agreed goals and targets; the Zero Hunger Challenge (to end hunger and malnutrition and assure food security for a growing population); climate change adaptation and mitigation, especially in the light of the Paris Agreement adopted at the UNFCCC COP21 embodying a strong commitment to address climate change and give agriculture a prominent role in that process; to combat desertification and mitigate effects of drought, especially the strive to achieve a land degradation neutral world; to preserve biodiversity and the provision of ecosystem services. He further said that promoting soil health is fostered by the following core actions: i) establishing or strengthening inclusive soil health-supportive agricultural/environmental policies where appropriate, inclusive policies to promote soil health should be linked to agricultural and environmental policies so that their implementation provides multiple benefits. If existing, these policies can be reviewed, as appropriate, to mainstream soil health; ii) increasing responsible investment and positive incentives aimed at promoting soil health where appropriate, responsible investment in soil health according to the principles for responsible investments in agriculture and food systems should be increased.

Provision of positive incentives to those stakeholders who implement soil management while recognising the value of ecosystem services could be envisaged; iii) promoting secure land tenure rights as soil health is affected by secure land tenure rights being in place or not. Access and tenure rights are an important factors for soil health to be properly implemented by land users and to enable long-term planning; iv) fostering and strengthening targeted soil research enabling national research programs and their partners to work with land users to identify and address the constraints they face in increasing the ecosystem services provided by soils (i.e. soil productivity); v) preventing or minimizing soil degradation and restoring/rehabilitating degraded soils (including historically degraded soils). Soil degradation shall be minimized by promoting soil health, especially through soil conservation approaches that proved to be successful. Soil rehabilitation and/or soil restoration should also be a priority, returning degraded soils to productivity, especially in historically sound agriculture or other production systems currently under threat; vi) promoting effective education programs. Where appropriate, education on soils (formal or informal) should be strengthened. That could start with the reflection of their importance in the school's curricula and extending to more professional levels.

Capacity development on Soil Health should be enhanced so that more professionals are brought up-to-date on methods and tools; vii) establishing/strengthening soil information systems. Considering the living nature of soils, the assessment of their status should be a precondition to planning any soil health intervention. Soil data and information (including local knowledge) are essential for understanding soil conditions and trends in soil functions, as well as for targeting interventions to increase productivity. Where appropriate, national soil information systems should be established or strengthened to have solid monitoring capacities of soil condition in place; viii) fostering international cooperation/collaboration on soils. International cooperation on soils should foster the exchange of knowledge, technology and information. Various arrangements including “North-South”, “South-South” and “Triangular” cooperation could be used for that purpose; ix) promoting communication on soil health practices.Pursuing the efforts of the International Year of Soils 2015, she enlisted the following guidelines for soil health promotion and dissemination, 1. Minimise soil erosion 2. Enhance soil organic matter content 3. Foster soil nutrient balance and cycles 4. Prevent, minimise and mitigate soil salinisation and alkalinisation 5. Prevent and minimise soil contamination 6. Prevent and minimize soil acidification 7. Preserve and enhance soil biodiversity 8. Minimise soil sealing 9. Prevent and mitigate soil compaction 10. Improve soil water management.

Norah Omot, Asia-Pacific Association of Agricultural Research Institutions (APAARI), Thailand presented a paper on ‘Socio-economic Consideration for Soil and Plant Health Management’. She discussed the socio-economic implications of soil and plant health problems such as huge economic losses caused by crop yield loss and reduced reservoir capacity; negative impacts on the economy; farmers not getting enough income; poverty linked to land degradation where there is a lack of diversification of alternate livelihoods; soil degradation reduces food supplies and contributes to an increase in so-called ‘environmental refuges’; changes in population size and distribution; human health and nutrition. The farm characteristics were discussed as the agricultural sector is not made up of a homogeneous farms; farming enterprises differ widely and also, producers are a diverse set of people who have a variety of goals.

She also listed farmer motivations viz. liberty to choose and adopt; biophysical motivations; social motivation factors and economic factors. Socio-economic considerations viz. variable farm management practice and policy or program influencing the producers need to be looked into. Hence, socio-economic conditions need to be kept in mind to integrate policies on availability, access and affordability. Soil and plant health management designs have to be at different levels including at farmer levels, researcher/organization level. There is a need to analyse policies which are implemented at farmers’ level. Heavy losses lead to reduced livelihood so some policies, e.g. on technical inputs for farmers, may need to be supplemented for adoption. Integration of knowledge on farmer situation, plant/soil health management and policies is important to address both generic and specific issues.

Somchai Anusontpornperm, Kasetsart University, Thailand made his presentation on ‘Addressing Soil Health Issues for Policy and Capacity’. He elaborated various soil health- related issues like the presence of salt-affected soils (inland and coastal saline soils), acid sulphate soils, shallow and skeletal soils, organic soil, sandy soil etc. facing various forms of physical, chemical and biological degradation. Different obstacles to achieving good soil health in Thailand are small landholders (90%), low educational level of farmers, poor socio-economic conditions of farmers earning low income etc. He further talked about soil health-related policy issues of current and future Thai Government like collaborative farming, decreasing area under off-season paddy rice and rubber plantation, tailor made fertilisation, precision fertiliser management, mechanised agriculture, increasing area under organic farming, encouraging farmers to use Vetiver grass to control soil erosion and following Sufficiency Economy Philosophy and Sustainable Agriculture approach. He also elaborated capacity and the ability of Thai Institutes or organisations to cope with soil health issues with 12 land development regional offices and 77 land development stations, Department of Agriculture (DOA), 28 divisions of rice research and development, 23 rice seeds divisions, well established Department of agricultural extension, Departments of soil sciences in four agricultural universities, 49 academic institutions being part of departments or faculty of agriculture. He also said that there is insufficient number of well-trained soil scientists. The average yield of major economic crops like sugarcane, cassava and rice in Thailand for the last 10 years are almost stagnant at low level.

C Manoharachari, Osmania University, India presented on ‘Policy Issues related to Microbes, Fungi and Plant Pathogens with Reference to Soil and Plant Health’. He presented that sustainable agriculture is a worldwide keyword for agriculture in the 21st century in which microorganisms in soil take a decisive role. Microbes including fungi possessed wide potential as biocontrol and biostimulating agents. These abilities not only control diseases but also increase nutrients availability, accelerate the decomposition of organic matters which results in an anticipated increase of crop production besides maintaining sound environments. Microbial

diversity, microbial load and presence of indicator microorganisms are useful indices to study soil health. Rhizosphere microbiota alleviates the biotic and abiotic stresses by different mechanisms. There is a need for scientifically analysed database for pests and diseases in different geographical regions of India and other countries. The aspects of measurements of severity of disease symptoms, prediction of obtainable yields, inocula quality, virulence, the innovation of disease forecasting methodologies and creation of models need to be prioritised.

There is a need to predict the origin of next generation plant pathogens and the strengthening of Integrated Disease Management along with varieties performing well in all geographic regions. There is a need for strengthening studies on biodiversity and taxonomy of microbes. Development of consortia may enable more resilient plant phenotypes than single strains. Effective quarantine regulations are to be developed to prevent the entry of alien pathogens.

HB Singh, Banaras Hindu University, India presented on 'Current Scenario of Biopesticides in India: Regulatory Requirements for Commercialisation'. He informed that the bio-pesticides market scenario has been 3.5 billion dollars as against the synthetic pesticides of 45 billion dollars. The current scenario of the use of pesticides in India is 60% insecticides, 20% fungicides, 16% herbicides and 4% bio-pesticides. He presented the trends of synthetic pesticides and bio-pesticides use worldwide and projected that from 2033 the biopesticides market will overtake the synthetic pesticides.

Presently commercially registered microbial pesticides with Central Insecticide Board and Registration Committee (CIBRC), India are 970, Under 9 (38) registered products are 791 and under 9(3) there are 68, of 791 fungal and bacterial based bio-pesticides are 568 and 223, respectively. While of 68, 43 and 25 are fungal and bacterial bio-pesticides. Among the biopesticides, 355 products are of *Trichoderma viride and T. harzianum.*

He informed that as per the Gazette notification of Central Insecticide Board, Ministry of Agriculture dated, 26th March 1999 bio-pesticides have been put under Indian Insecticide Act 1968. Registration of the biopesticides has become mandatory before it is commercialized. Antagonistic fungi and bacteria viz. Bacillus *subtilis, Pseudomonas fluorescens, Gliocladium spp., Trichoderma spp.* and entomogenous fungi and viruses viz. *Beauvaria bassiana, Metarrhizium anisopliae, Verticillum lecanii, Grannulosis viruses, Nuclear Polyhedrosis Viruses* have been included in the Gazette for production. There are 25 microbial pesticides i.e. N*omurea rileyi, Hirsutella species, Verticillium chlamydosporium, Streptomyces griseoviridis, Streptomyces lydicus, Ampelomyces quisqualis, Candida oleophila, Fusarium oxysporum* (non pathogenic), B*urkholderia cepacia, Conithyrium minitans, Agrobacterium radiobacter strain 84, Agrobactarium tumefaciens, Pythium oligandrum, Erwinia amylovora* (hairpin protein), *Phlebia gigantean, Paecilomyces lilacinus, Penicillium islandicum* (for groundnut), *Alcaligenes spp., Chaetomium globosum, Aspergillus niger* – strain AN27, VAM (fungus), *Myrothecium verrucaria, Photorhabdus luminescences akhurustii strain K-1, Serratia marcescens GPS 5, Piriformospora indica* included in the schedule of the Insecticide Act, 1968. He gave the basic information required on the product for registration viz. strain specifications,colony forming units count, Target fungi, Moisture Content, Type of formulation, Technical, bulletin/ Product profile and the requirement of each viz. CFU count & Shelf life, moisture content, chemistry, bioefficacy, toxicity, packing and labelling, etc. He informed about the bio-pesticides formulations viz. T*richoderma harzianum, Beauveria bassiana, Bacillus subtilis* registered with Central Insecticide Board and Registration Committee and patents received by him.

Wayne Nelles, Higher Education and Partnerships Consultant, Asia-Pacific Association of Agricultural Research Institutions (APAARI) & Canadian Visiting Scholar, Chulalongkorn University School of Agricultural Resources (CUSAR), Bangkok presented a paper on 'Interdisciplinary and agro-ecological perspectives for higher education reform to meet SDGS: with Implications for soil and plant health studies'. He presented the aspects of global soil and plant health agreements, policy trends, research and extension on soil and plant health: Interdisciplinary Assumptions, Technical Debates and Pedagogical

Challenges for Higher Education Institutions (HEIs). FAO Scaling-up Agroecology Initiative i.e. Transforming Food and Agricultural Systems in support of the SDGS, Implications for HEIs (Soil/Plant Health) and Proposed APAARI Higher Education Projects and Partnerships for Strengthening Agroecology i.e. Learning and Research Themes Including Soil and Plant Health with other components.

In research systematic program and institutionalised linkages have not allowed universities' researchers to apply their research outputs to farmers, or sufficiently collaborate with farmers (much less in deploying agroecology content or methods). Dr Nelles also covered the project on Sustainability in ASEAN Higher Agriculture Education; the Project on Transitioning to Green Agri-food Systems, Rural Sustainability and Healthy Communities while meeting SDGs in Southeast Asia; Recent Global Soil and Plant Health Agreements, Related Policy Trends and Unresolved Conflicts (Contested Evidence and Action); Sustainable Soil Management (SSM) Concept; Global Assessment: Impact of Plant Protection Products (PPPs) on Soils; Agroecology; GRET-Agroecology Learning alliance in South East Asia (GRET-ALiSEA) Agroecology Study (2015) Critique; Recent Calls for More Diversified, Multi-functional Agrifood Systems (2016); Soil enhancement/ Crop protection and Food Security through Agroecology or Organic Methods; Issues for Soil-Plant Health Teaching, Research and Extension in HEIs; Selected disciplines that could collaborate to better document, understand or improve Soil and Plant Health; Cross- Cutting Policy Issues implicating Multi-Disciplinary Study or Teaching of Soil or Plant Health, Biological or Evolutionary Factors on Soil or Plant Health (Physical Dimensions); Contentious Issues in Soil Health and Plant Protection unresolved; FAO's Scaling-up Agroecology Initiative for SDGS (Implications for Science/ HEIs- Educational Challenges and Opportunities and Opportunities to scale up Agroecology):Transforming Food and Agricultural systems in Support of the SDGS; Background and Implications for Sciences and HEIs; Asia-Pacific Agro- Ecological Research, Education & Extension Challenge (FAO 2015, Conference Recommendations); Proposed HEI Partnership Initiative for Agroecology-APAARI with Partners; APAARI Agroecology HEI Project; and Recommendations (Implicating APAARI, Soil and Plant Health Studies in/with HEIs).

The other panel speakers were Janiz S Binamira, Philippines, Chongrak Wachrinrat, KU, Thailand and Mary Atieno, CIAT, Vietnam reiterated the relevant points on capacity development for farmers, policy implications of soil health on forestry and capacity development in the field of microbial technology. Important points made by these speakers have been covered in the recommendations.

Plenary Session
Co-chairs: Yuxin Tong, Sermsuk Salakphet, Ravi Khetarpal

Consolidated Recommendations of Sessions

A big group of soil and plant protection scientists made a large number of presentations in nine technical sessions spread over three days covering a range of subjects within the ambit of soil and plant health under the changing climatic scenario focussing on achieving the SDGs in the Asia Pacific. There were several intense sessions followed by comprehensive discussions. All these discussions were translated into recommendations as detailed below.

Soil Health: presented by Dr CL Acharya

Priority Research Areas

- On restoration of soil health of impoverished and problematic soils with respect to their physical, chemical and biological attributes (using manure, crop residues and other resources resulting in reduced fertiliser application), reduction in input of agricultural chemicals, biodiversity conservation, dynamics of organic matter in soil particles, functionality of organic matter in soil, adopting soil health management measures to cope with climate change in sustainable way.

- Soil polluting contributors such as excessive use of chemicals, pesticide residues, indiscriminate use of fertilisers, urban and industrial effluents entering irrigation water, over mining of underground water loaded with heavy metals, use of poor quality organic manure prepared from municipal and industrial solid wastes, crop residues burning and deposition of byproducts, fossil fuel combustion and mining are to be minimised.

- Identification of pesticide and heavy metal decomposing/fixing microorganisms; collection, isolation, identification of soil micro- organism capable to act as a pest and disease controlling agents for the development of bio-pesticides, genome analysis of soil microorganisms, quantification of accumulated chemical residues (nutrients and heavy metals) in soil and its impact on plants and environment, developing environmentally friendly inputs, rational and safe pesticide management are to be prioritised.

- Explore the use of nano-technology and nano-biotechnology for higher fertiliser use efficiency and to scavenge heavy metals and arsenic from soil-water-plant system, fertiliser and crop management strategies for the reduction of greenhouse gas emissions from agricultural lands.

- Focus on soil microbial diversity on greenhouse gas production and soil structure and the effect of long-term use of a soil management practice on the amount of atmospheric carbon sequestered in the soil in comparison to forest ecosystems. C-sequestration as adaptation and mitigation strategy to climate change, use of on-farm wastes through composting – microbial consortia cultures, vermicomposting, etc. for improving soil microbial health.

- Conducting research on new bio-fertilisers know-how, bio-fertilisers/microbial inoculants, slow or controlled-release fertilisers, organic agriculture, smart agriculture, precision agriculture, monitoring soil condition (nutrients, water) by remote sensor set on UAV (drone) and tractor combined with satellite data, ICT, metadata analysis and Artificial Intelligence.

Capacity Development

- Enhance the scientific capacities in the field of microbial technology with the help of microbial platform established within and outside the region that shall lead to sustainable soil health improvement.

- Empowerment of Association of Southeast Asian Nations (ASEAN) farmers as Soil Health Champions, through capacity building based on participatory and interactive learning processes, and local testing towards the customization of technological packages, quality farmer education enabling them to create new knowledge and allowing farmers and researchers to use complimentary local and scientific knowledge to test farmers' own context-specific solutions while improving their knowledge on soil functions and ecological processes.

- Integrating Farmer Field Schools into the frame work of the Association of Southeast Asian Nations-Guidelines on Soil and Nutrient Management (ASEAN-GSNM) enabling farmers to create new knowledge and focus on developing farmers' skills on agronomic and ecological factors.

- Farmers to farmers training (from soil status assessment to problem identification and solving), on a volunteering basis, building capacity of small-holder farmers on the practice of sustainable soil management (SSM) supporting governmental agencies and organizations working on agricultural extension at the field level; encouraging disseminating good practices and integrated communication technologies involving training and capacity building in soil health management.

- Establishing good linkages between education and extension to enhance the quantity and quality of soil data, information, supporting national soil monitoring activities, implementation of the Global Soil Doctors programme in Asia, field research based on interactions between universities and research institutes with the Soil Doctors, access to demonstration and experimental fields; introducing the importance of soil resource and its care in the text books at schools and extending it to more professional levels.

- Promoting technical and scientific cooperation among countries for improving soil testing procedures, and to link to the Centre of Excellence for Soil Research in Asia (CESRA), the Global Soil Information System (GLOSIS), proposed Asian Soil Information System (ASIS), the Global Soil Laboratory Network (GLOSOLAN) and the Regional Soil Laboratory Network for Asia (SEALNET) as foreseen in the Asian Soil Partnership (ASP) implementation plan.

- Creation of regional soil health village as a centre of excellence of soil management research and human resource development; establishment of National Soil Health Program; providing Soil Health Cards to the farmers, development of sustainable soil management expert systems, DSS tools for site-specific nutrient, organic matter and lime recommendations (for acid soils), guidelines for soil health assessment, and monitoring soil health indicators; contribute to soil organic carbon mapping (SOC map) and bringing out technical publications like Soil Atlas of Asia.

- Implementing a watershed management program for reduction of soil erosion; identification of polluted soils (location, type and degree of pollution), an action plan for mainstreaming and scaling out sustainable land management (SLM).

- Encouraging farmers to adopt conservation agriculture (CA) practices with crop residues retention at the soil surface, rather than their burning, to protect and enrich soil health and promote carbon sequestration, providing incentives and rewards to farmers maintaining high soil organic carbon and good soil health.

Infrastructure Development and Investment

- All soil testing laboratories, especially district and regional laboratories, should be well equipped for the analysis of available macro and micronutrients and quality of irrigation water, plant tissue testing, for providing advisory services for general as well as for specialized farming including horticulture, floriculture and plantation crops having qualified and trained staff with some incentives, having provision of training and updating on a regular basis.

- Need for creating centralised state of the art infrastructure for analysing soil, water, plant tissue testing and fertilisers district-wise.

- Upgradation of selected labs in the regions as referral labs with strong monitoring mechanism for cross- checking or referencing of soil testing data, options for public- private partnership to run the referral laboratories using principle of soil clinics, diagnosis and recommendation at a reasonable cost.

Public Awareness

- Farming community to be made aware of soil erosion, various losses due to soil degradation, and benefits of soil health improvement through action learning tools; increasing public awareness on soil's socio-economic aspects, and approaching demand- driven water management.

- Public communication/education with additional budgetary provisions is essential to create awareness that due to soil pollution it is becoming difficult to strike a balance between profitability and environmental quality/food safety. There are conflicts between soil regulation and food regulation on these aspects.

- Facilitating interactive processes involving a range of entities and stakeholders; interacting with regional soil science societies, providing guidance on regional goals and priorities. Considering the living nature of soils, the assessment of their status (including local knowledge) should be a precondition to planning any soil health intervention.

- Observing the World Soil Day campaign, laying of demonstrations, making the public aware of soil contamination with heavy metals, encouraging investment, technical cooperation, policy and education on soil health are the key issues.

Policy Advocacy

- Enacting Law on Soil Conservation, Registration and Quality Control of Fertilisers, Organic agriculture as an Act, development of the national soil standards, soil contamination with heavy metals, policy support on mining, safe disposal of municipal wastes and industrial effluents, against crop residue burning, land use policy protecting productive lands being used for purposes other than agriculture like conversion to wasteland by brick kiln industry.

- Gathering scientific evidence for policy development on the role of SOC for climate change, food security and

SDGs agendas, sustainable soil and water management, starting soil quality monitoring project in agricultural lands, adoption of soil conservation guided farms, conservation farming village program, improved Sloping Agricultural Land Technology (SALT) system for sustainable crop production, use of alternate energy sources such as solar and wind power in agriculture. Where appropriate, national soil information systems should be established or strengthened in order to have solid monitoring capacities of soil conditions in place.

- Policy on providing incentives rather than punitive measures to farmers promoting greater N-use efficiency, providing carbon-credit or incentives to the farmers practicing CA with in-situ crop residue retention for C sequestration, soil health improvement & GHG mitigation, instituting Best Soil Health Maintaining Farmer Award and provision of positive incentives to those stakeholders who implement efficient soil management while recognizing the value of ecosystem services served by soils.

Possible Partnership

- There is a need to built partnership and networking in the programs like enhancing soil biodiversity work through the Global Assessment of Soil Biodiversity, Establishment of the GLOSIS including the Monitoring System of the GSOC map, in the implementation of activities of the ITPS including the collaboration with IPCC and United Nations Convention on Combat Desertification (UNCCD), INBS, GLOSOLAN and Soil Doctors Program, collaboration in the execution of regional implementation plans (field activities), implementation of activities of INSII, working together with partners to combat food insecurity and malnutrition.

- Establishing GLOBAL SOIL PARTNERSHIP as a mechanism to develop a strong interactive partnership, enhanced collaboration and synergy of efforts between all stakeholders, soil institutions for Soil Information System, conservation and restoration of soil health, soil research and extension, education and policy, awareness-raising, sharing and exchange of knowledge, experience and expertise on soil management as steps towards maintaining healthy soils.

- Since soil Health/Quality impacts environmental quality and the answer to the challenges of climate change lies in the soil, there is a need to develop a Regional Knowledge Platform on Soil and Plant Health in the APR by FAO in association with APAARI to access and share the new knowledge and technologies within and outside the region.

Plant Health: presented by Dr KS Varaprasad

Research

- Enhanced research on Plant Growth Promoting Rhizobacteria, biocontrol agents, endophytes, Arbuscular Mycorrhizal Fungi and other microbial wealth- bio resource characterization and conservation.

- Developing efficient delivery mechanisms including standardization of nano particles for biological agents on integrating soil, water and nutrient management for plant health.

- Regional collaboration for disease resistance breeding of crops and diseases relevant to the region.

- Combination of bio and chemical pesticides and consortia for enhancing trade with acceptable residue levels and plant health indicators development and DSS. The response of pests and diseases to climate variation and extreme events be investigated as a proactive step.

- Validation of ecofriendly/traditional plant health management practices.

- Scientific assessment of prioritised crop losses in the region.

- Diagnostic tools development for races/ pathotypes and complex species prioritised for the region.

- Phytosanitary treatments (alternatives to Methyl Bromide, bulk consignments).

- Scientists may focus on the biosecurity needs of the region.

- Integrating soil, water and nutrient effects on plant health.

Capacity-building/ Development

- Strengthening taxonomy of fungi and other mi-crobes in APR as relevant to SDGs based country and region-specific modules for soil and plant health to be developed

- Massive Open Online Courses (MOOCs) and other Information and Communication Technology (ICT) modules to be developed in regional languages

- Create partnerships for knowledge dissemination

- New Knowledge Management APAARI Platform

- Efforts be made to integrate plant health professional societies of India into one common platform at the national level and to plan activities for International Year of Plant Health 2020

- Farmer champions and Farmer Field Schools Centre of Excellence for diagnostics and certification (Citurs greening disease and viruses-ICAR-National Research Centre for Citrus); exotic viruses – ICAR-National Bureau of Plant Genetic Resources (NBPGR); Banana and orchid viruses – ICAR Indian Agricultural Research Institute (IARI) to help the region in preventing transboundary movement of pests.

- Access/ develop Containment/ Biosecurity facility for research on exotic pests

- Regional capacity building in the field of biosecurity and biosafety

Policy

- Upscaling of biocontrol agents such as Trichoderma and bio-pesticides in APR modifying as per local needs including capsule technologies involving youth as entrepreneurs

- Review guidelines particularly for biopesticide registration, commercialization of microbial technology relevant to the region

- A database of proven technologies in soil and plant health management be developed

- Based on specific needs of a group of countries development projects for upscaling of prioritised technologies

- Pest surveillance (lack of human resource, use of latest technologies). Recently introduced pests (Fall armyworm, wheat blast, Wheat streak mosaic virus) diagnostics and eradication to prevent their further spread be prioritized.

- Pest categorisation in the region for biosecurity.

- Regional cooperation for pre-export inspection.

- A roster of experts on soil and plant health be made.

- Networking of regional referral laboratories.

- Asia Pacific Plant Pests Diagnostic and Certification Network be developed

- Developing Policy Briefs for the identified countries.

Development of Regional Knowledge Platform on Soil and Plant Health

APAARI should take initiative for developing a 'Regional Knowledge Platform on Soil and Plant Health' in the APR by FAO to access and share the new knowledge and technologies within and outside the region. The major objectives of the Regional Knowledge Platform are:

- To create awareness on soil and plant health management towards achieving SDGs

- To bring players of research, development, extension and communications on one platform for complementing the activities of existing global and regional partnerships and networks

- To document and share the success stories of soil and plant health management for the benefit of countries in the region and its eventual scaling up and scaling out.

- To regularly share the latest information on research, development and technologies on soil and plant health management among the members.

- To identify, promote and facilitate capacity development in various important areas of soil and plant health management

- To identify and reward champion farmers in soil and plant health management in the region.

- To influence the governments to have appropriate policies for soil and plant health management.

- To promote partnerships and networking for the cause of soil and plant health management.

Governance

- To appoint a Coordinator for the Platform/ Consortium. Tenure can be three years at a time and preferably a staff of the hosting Institute.

- To have members from among National Agricultural Research System, Higher education sector, FAO of UN, related Networks, International organizations viz. Consultative Group on International Agricultural Research (CGIAR), Association of International Research and Development Centers for Agriculture (AIRCA), etc. Associations, NGOs, CSOs, Private sector etc.

- Members may be beyond the Asia-Pacific also

- Membership fee

- Host Institute/ Country to be identified

APAARI Action Points

- Facilitate creation of Regional Soil and Plant Health Knowledge Platform with FAO/other international bodies for taking up the following activities:

- Bring awareness on the issue of crop residue management technologies to avoid burning that causes soil and environmental pollution.

- Develop focused capacity building modules and policy briefs and facilitate collaborative projects on different aspects of soil and health management directed to all levels of stakeholders including policy makers.

- Facilitate workshops/meetings to promote partnerships/networks with the private sector and related to international funding opportunities for promoting soil and plant health.

- Facilitate studies on impact assessment of successful technologies on soil health and document the same to promote the use of those technologies that contribute to achieve SDGs in the APR.

- Facilitate regional linkages with the Centre of Excellence for Soil Research in Asia (CESRA).

Annex I
List of Participants – IPS Delegates

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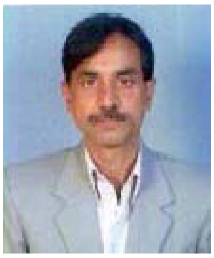
47	Radha Raman Pandey	Professor, Department of Life Sciences, Manipur University, Canchipur, Imphal- 795003	India	pandey.rr@ rediffmail.com; rrpandey.mu@ gmail.com	
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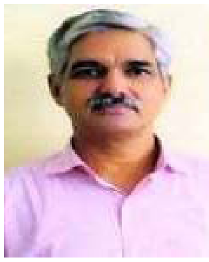
52	Ramji Singh	Professor Plant Patholo- gy, Department of Plant Pathology, College of Ag- riculture, SVPUAT Meerut	India	singh.ramji@gmail. co m	
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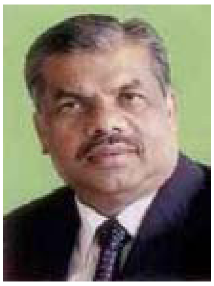
71	Siddapura Ramachandrappa Niranjana	Vice-Chancellor, Gulbarga University, Kalaburagi - 585 106, Karnaktaka	India	vcgug@rediffmail. com; niranjanasr@ rediffmail.com	
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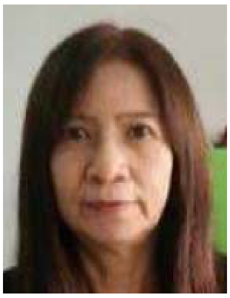
3	Areewan Jaipet	Biological Control Promotion Group, Plant Protection and Soil and Fertilizer Management Division, Department of Agricultural Extension (DOAE), 2143/1 Phaholyothin Rd., Chatuchak, Bangkok 10900	Thailand	areewan @hotmail.com	
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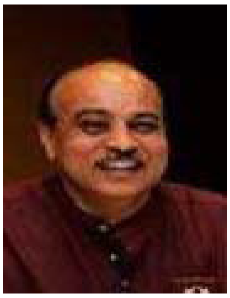
24	Mahadev Bassana Chetti	Vice-Chancellor, University of Agricultural Sciences, Krishinagar, Dharwad- 580005, Karnataka	India	vc@uasd.in; mbchetti_uas@rediffmail.com	
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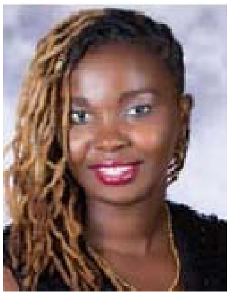
26	Mary Atieno Otieno	Soil Health Consultant, CIAT Asia-International Center for Tropical Agriculture (CIAT), Agricultural Genetics Institute, Pham Van Dong, Tu Liem, Hanoi	Vietnam	matieno766@gmail.com	
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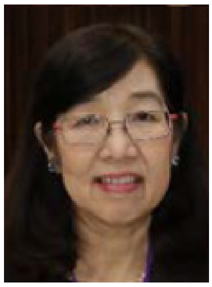
32	Panchaporn Lertrat	Senior Expert in Soil and Fertilizer, Agricultural Production Sciences Research and Development Division, Department of Agriculture, 50, Paholyothin Road, Chatuchak, Bangkok 10900	Thailand	panjaporn99 @hotmail.com	
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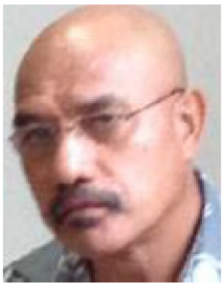
43	Siosiua Moala Halavatau	Crop Production and Extension Coordinator, Pacific Community, Land Resources Division, Private Mail Bag, Suva	Fiji Islands	siosiuah@spc.int; halavatauj@gmail.com	
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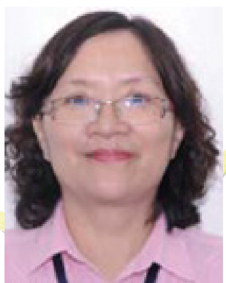
60	Yu-Wen Lin	Associate Researcher, Soil and Plant Analysis/Soil contamination, Taiwan Agricultural Research Institute, 189 Zhongzheng Rd., Wufeng, Taichung City 41362	Taiwan	ywlin@tari.gov.tw	

#	NAME	DESIGNATION/ ORGANIZATION	COUNTRY	EMAIL	PHOTO
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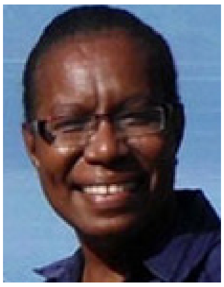
64	Norah Omot	ASTI Co-ordinator, Asia-Pacific Association of Agricultural Research Institutions (APAARI), 182 Larn Luang Road, Klong Mahanak Sub-District, Pomprab Sattrupai District, Bangkok 10100	Thailand	norah.omot@apaari.org	
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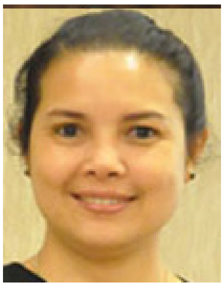
68	Thansita Tanaphatrujira	Operations Associate, Asia-Pacific Association of Agricultural Research Institutions (APAARI), 182 Larn Luang Road, Klong Mahanak Sub-District, Pomprab Sattrupai District, Bangkok 10100	Thailand	thansita@apaari. org	
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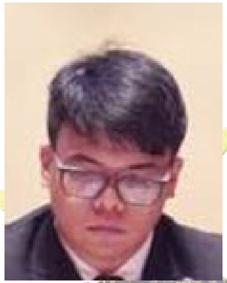
72	Pisuth Suvannasankha	Moderator, Agricultural and Food Marketing Association for Asia and the Pacific (AFMA), FAO Annex Building, 202/1 Larn Luang, Bangkok 10100, Thailand	Thailand	pisuth@afmaas- ia.org	

Annex II
Technical Programme

Regional Conference on Role of Soil and Plant Health Towards Achieving Sustainable Development Goals in Asia-Pacific

21-23 November 2018, Hotel Rama Gardens, Bangkok

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, In
	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 Varap		
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 Develoment 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

South and West Asia (cont...)		
(11:40-13:00) – (14:00-15:30)	South and West Asia	
	India	S.K. Chaudhari, ICAR
	Nepal	Mr. Krishna Bahadur Thapa
	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
	Papua New Guinea	Akkinapally Ramakrishna
	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		
16:00-17:30	Key note Lecture: Sustaining agricultural produc-tivity under climate change scenario in Asia Pacific – Rice as a case study	U.S. Singh, IRRI
	ASEAN Farmers: Soil health champions in Asia	Jainz S. Binamira, FAO Consultant, Department of Agriculture, Philippines
	Soil health management - issues & concerns for sustainable development	Girish Chander, ICRISAT
	Soil health : research and development	Bunjirtluk Jindaridth, DOA, Thailand

Technical session II (cont...)		
	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-India
	Role of soil health in achieving sustainable development goals	Himanshu Pathak, ICAR-India
	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-IIS
	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, BARC
	Bhutan	Tashi Uden, DOA
	India	C.D. Mayee, Ex-ICAR-ASRB
	Bhutan	Tashi Uden, DOA
	Nepal	Deepak Bhandari, NARC
	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

South East Asia and Pacific (cont...)		
	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 Commercial Co-chairs: Dileepkumar Guntuku, JP Sharma Rapporteur: Fai Collins (Venue: Tulip Hall)	
	Role of digital technologies	Dileepkumar Guntuku, IS
	Coordination among phytopathological societies for quality improvement	S.S. Chahal, Ex-VC, MPUA
	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 Chetti 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: Dilip K. Ghosh (Venue: Tulip Hall)	
	Key note Lecture: Plant disease management with eco-friendly bio-pesticides	A.N. Mukhopadhyay, Ex-VC
	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

Technical Session V (cont...)		
	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
	Microbes for improving soil and plant health in spice crops	M. Anandaraj, Ex-ICAR-IIS
	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-NBPG
	Minimizing risk of introduction of exotic pathogens as-sociated 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

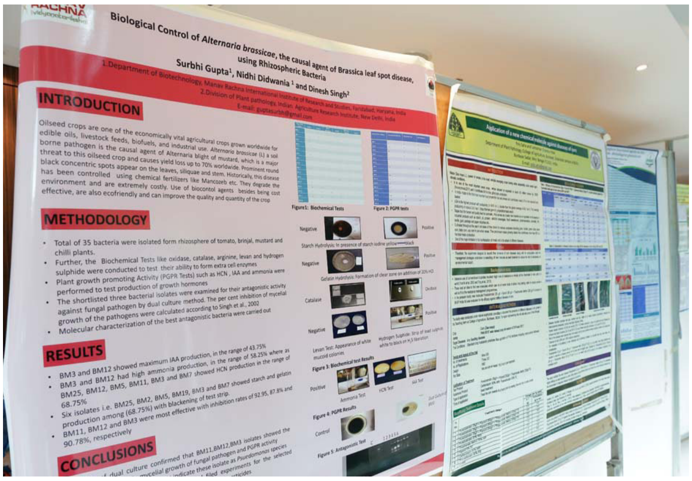
Technical Session VI (cont...)		
	Fungal Endophytes: A treasure trove of biodiversity, host security, antimicrobial and myconanotechnology	Ravindra Nath Kharwar, BH U
	Bipolaris - Curvularia - Cochliobolus Complex – their phylogenetic and taxonomic re-evaluation and DNA barcoding	T. Prameela Devi, ICAR-IARI
	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, Suseelendra Desai Rapporteur: Vaibhav Kumar Singh (Venue: Canna Hall)	
	Wheat blast - A recent danger to wheat production in South Asia and our preparedness	Vaibhav Kumar Singh, ICAR
	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
	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 agrochemi-cals on growth of Rhizobia	S.S. Kamble, SU
	Studies on black rot cabbage caused by Xanthomonas campestris pv. campestris	K.B. Yadahalli, UAS

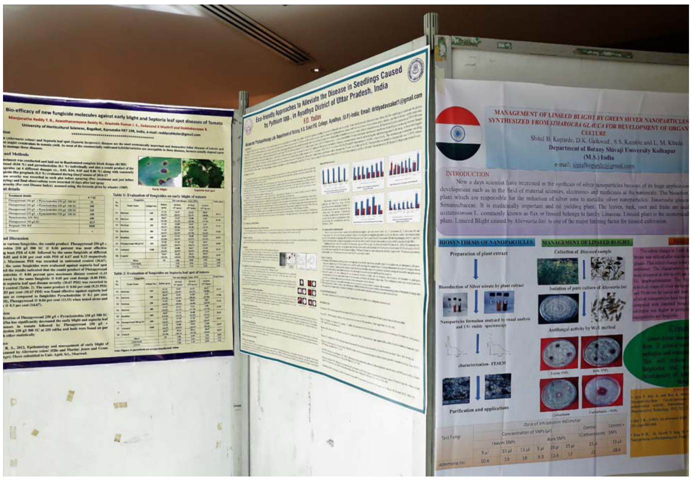
Technical Session VII (cont...)		
	XopC2 T3SS effector of Xanthomonas axonopodis pv. punicae suppresses pomegranate immune responses to support bacterial growth during blight develop-ment	Kalyan K. Mondal, ICAR-IAR I
	Improvement of soil health through enriched spent mu-shroom substrate (SMS) and its effects on plant health, productivity and wilt incidence of tomato	Mohan Kumar Biswas, IA-VisvaBharati
	Correlation of weather parameters with develop-ment 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 Trend 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 me-dicinal 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, OU
	Evaluation of resistant tomato germplasm against to-mato yellow leaf curl disease to improve crop produc-tivity 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

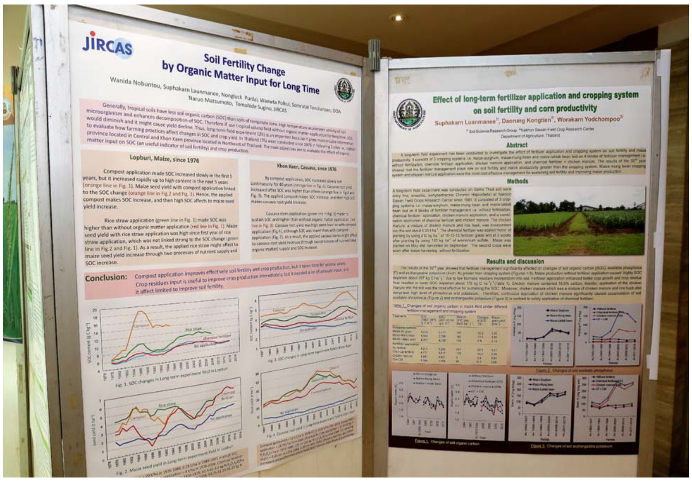
Day 3: Friday, 23 November 2018		
Technical session IX: Panel Discussion Policy and Capacity Development on Soil and Plant Health Co-Chair: S.K. Chaudhari, S.R. Niranjana Rapporteur: Pratibha Sharma (Venue: Canna Hall)		
Implications 09:00-12:30	Flagging issues on soil health	C.L. Acharya
	Flagging issues on plant health	K. S. Varaprasad
	Capacity development for farmers on soil and plant health	Jainz S. Binamira, 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
	Policy issues related to microbes, fungi and plant pathogens with reference to soil and plant health	C. Manoharachary, OU
	Current scenario of bio-pesticides 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 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, KU
	Remarks by Co-organizers	Surmsuk Salakphet, DOA R.N. Pandey, IPS U.S. Singh, IRRI
	Vote of thanx	Rishi Tyagi
Departure		

Event Photos

Welcoming the dignitaries







Registration - Posters - Meet and greet - Publications

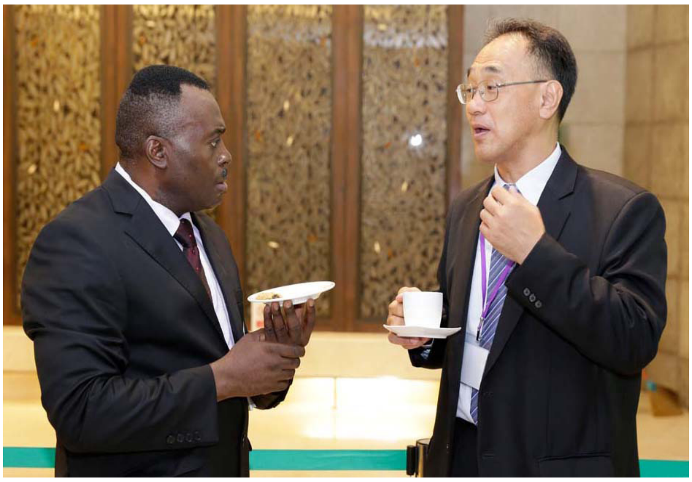
Inaugural Session and felicitations

Participants and Discussions




Expert presentations








Networking, informal discussions and administrative

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